RICHEY

THE BUILDING MECHANICS' READY REFERENCE

PLUMBERS' STEAM-FITTERS' AND TINNERS' EDITION

BY

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SUPERINTENDENT OF CONSTRUCTION U.S. PUBLIC BUILDINGS

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PREFACE

In preparing this volume of "The Building Mechanics' Ready Reference," it is not intended by the author to make the book a treatise or text-book on any particular branch or subject of the trades covered; but he will endeavor to give to the Plumbing and Steam-fitting trades a book that will be as its title implies, — a ready reference.

It is intended to prepare the book so that it will be a valuable assistant as a reference to anyone connected with the plumbing or steam fitting trades, either in the office or on the work.

In addition to the original matter presented, the author has compiled and brought together a large amount of useful information and arranged it in such shape that any subject or any information desired can readily be referred to, and in doing this he has been rendered great assistance through the kindness of numerous manufacturers, and the editors of various trade papers.

In this one, as in the preceding volumes of "The Building Mechanics' Ready Reference," a large amount of information has been arranged in tabular form so as to be more convenient for quick reference and use.

The author will be pleased to hear from any reader regarding any error, typographical or otherwise, found in this work, or any idea or suggestion that may be useful in a future edition; address the author, care of the publishers.

H. G. Richey.

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PART I.

WARM AIR HEATING. STEAM HEATING. HOT WATER HEATING. MISCELLANEOUS HEATING DATA. PIPING OF HEATING SYSTEMS. PIPE FITTINGS.

WARM AIR HEATING.

Location of the Furnace. — The proper location of the furnace, as well as the size and arrangement of the hot air pipes, is one of the most important points to be considered for its successful operation.

The position of the furnace should be as central as possible as regards the runs of conducting pipe and the register outlets, so that the pipes will all be of nearly equal length, and no pipe will have an advantage over another. If one side of the building is more exposed to the weather than another, it should be favored; the reason for this is that warm air, being a vapor, is affected by the winds, and when the wind is blowing strong the tendency is for the rooms on the side of the house from the wind to be overheated, while those rooms receiving the blunt of the wind will be poorly heated.

Therefore, to counteract this tendency the furnace should be located a little nearer to the side of the house mostly exposed to the weather, and thus shorten the runs of conducting hot air pipes on that side. Or in case there are one or more rooms in the house which it is desired to heat to a higher temperature than the others they can be favored in the same way by locating the furnace a little nearer the registers of these rooms than the others.

Foundation of Furnace. — The furnace, whether portable or encased with brick, should rest on a solid brick or concrete

foundation, the plan of which will have to be governed by the style and make of the furnace, and the method adapted of supplying the cold air.

In case an underground duct is used for the supply of cold air then there must be a pit for the furnace as well as foundation, this pit being built in and forming a part of the foundation.

If there is any danger of dampness or water especial care

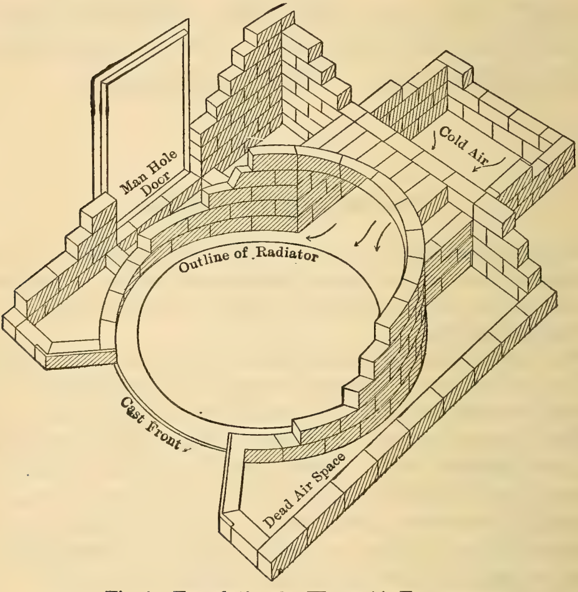


Fig. 1. Foundation for Warm Air Furnace.

should be taken to make the pit water-tight, and it should be plastered thoroughly both inside and outside with cement.

In the center it is well to build up a pier to carry the central weight of the furnace, the framework of some furnaces not being strong enough to support the weight they have to carry without this pier.

Often it is necessary to build a pit even when there is no underground air duct; the furnace should be set low enough so that there will be a rise of not less than 1 in 10 to the warm air pipes,

and if possible there should be more, as the more rise the faster the warm air will be supplied to the rooms; thus a pit is often necessary in low basements or cellars.

Fig. 1 shows a foundation and pit for a warm air furnace; the cold air duct as shown is connected either to the underground duct or to the overhead duct as the case may be.

THE COLD AIR DUCT. — Having decided on the point from which the supply of fresh air is to be taken, and which should be as near to the furnace as possible, the next problem is to

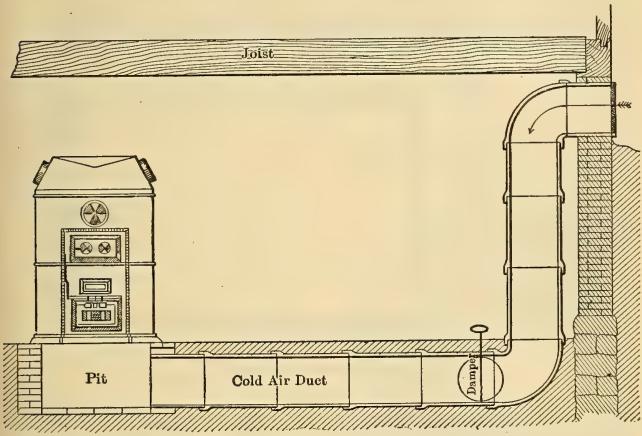


Fig. 2. Underground Cold Air Duct.

decide the size and character of the duct to convey the air from the outside of the building to the furnace.

As the air to supply all the registers of the building is to come through this duct it would seem that it should be of a capacity equal to the total area of all the warm air pipes; this, however, is not the case, as the air on entering the furnace expands and on rising through the pipes causes a vacuum which the air from the outside duct fills.

The warm air in rising also usually has more angles and obstacles to overcome than that of the air duct, and the air in passing through this duct can pass more rapidly than that which is passing through the warm air pipes. Thus it is safe to estimate that a cold air duct of two-thirds the capacity of all the

warm air pipes will be sufficient to supply all the fresh air needed; hence we can deduct the following rule: — To find the size of cold air duct required, add together the areas of all the warm air pipes to be supplied, and two-thirds of this sum will be the area required for the duct. For the areas of various size pipes see the table on page 151.

The circumstances of the case will usually govern the character of construction of the air duct. A duct made of tile as shown by

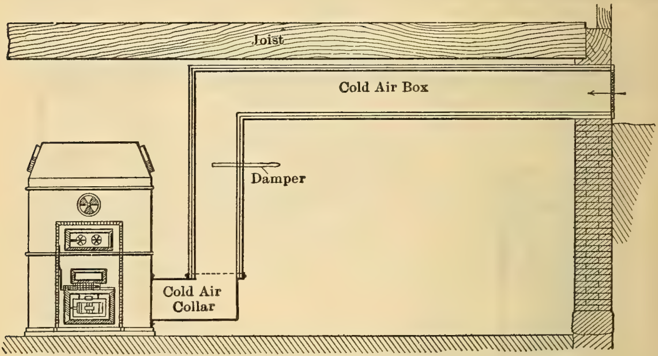


Fig. 3. Overhead Cold Air Duct.

Fig. 2 is often used, as it is simple and easy to construct for an underground duct. The duct should never be put underground if there is any sign of water or dampness; in such cases it should be brought in overhead and down to the furnace as shown by Fig. 3.

If the duct is taken from a sash or window opening and made of tin or sheet iron, it is a good plan to make a flanged box or inlet to fit the sash or opening, and start the duct from this box which should extend a foot or more from the opening.

If the duct is made of wood, it should be of matched boards and made of two thicknesses with a layer of asbestos paper between, so as to make the duct as near air-tight as possible.

In many cases it is desirable to return air to the furnace from the rooms above, to be reheated and returned to the rooms again as warm air; these return ducts should always be installed where the winter temperature falls below zero, and should always be

installed in addition to and in connection with the cold air duct from the outside.

The return duct may be built of wood, iron or tin, and can be run in connection with the fresh air duct from the outside.

The return duct should draw its supply of air from the coldest part of the house, as a hall or vestibule.

The area of the return duct should be about two-thirds that of the fresh air duct, and the two ducts should be arranged with dampers so that either can be used independent of the other, or they can both be used at the same time.

Fig. 4 shows how the cold air duct can be taken from a window and also take air from the room above; the damper is put in as shown and will shut off either source of supply or will allow both to be used at the same time.

Fresh Air Regulating Duct. — Fig. 5 shows the construction of a cold air duct to a furnace which is so arranged that the one duct will carry the fresh air from the outside and the return cold air from the heated rooms when desired.

The duct is built as shown, with a swinging door inside; a chain is run from the door through a pulley and a weight attached to keep the door in the position shown, thus allowing the fresh air from the outside to be admitted to the furnace; another chain is to be attached to the other side of the door, run through a pulley and then up through the floor, where it is to be adjusted by means of a hook on the baseboard of the room.

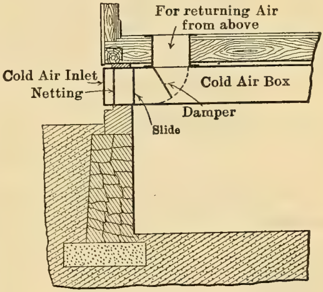


Fig. 4. Cold Air Inlet.

When it is desired to shut off the outside supply of fresh air all that is necessary is to pull the chain and fasten the door in the position shown by the dotted lines; the air then to supply the furnace is taken from the rooms above and returned to the furnace to be warmed and circulated to the rooms again. By adjusting the door in the duct, air can be taken from the outside and from the rooms above at the same time.

Cold air ducts are often placed in such a location that the

wind from certain directions will enter the duct and circulate through the furnace so rapidly that it is not warmed, but enters the rooms cold.

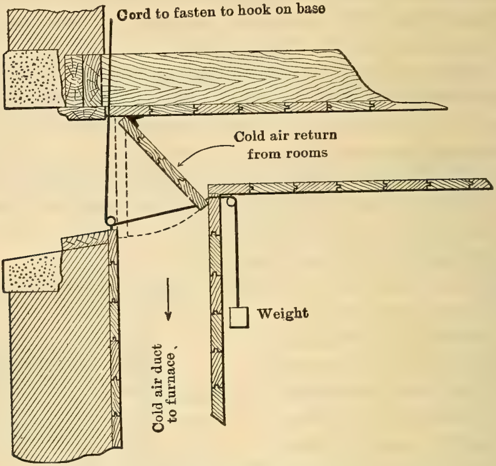


Fig. 5. Cold Air and Return Duct.

To prevent this a swinging damper should be put in the duct as shown by Fig. 6. A strong current of air or gust of wind will

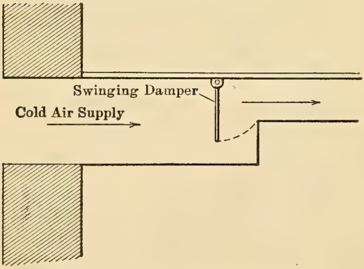


Fig. 6. Cold Air Regulator.

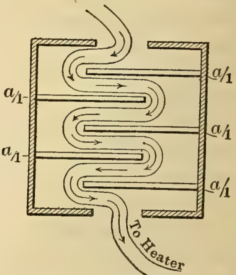


Fig. 7. Baffle Plates.

cause the damper to close, thus shutting off a too rapid supply of cold air.

The entrance to the cold air duct should always be covered

with a wire screen to prevent vermin, leaves, etc., from entering the duct.

In some localities where there is much dust and sand, much of it may be drawn into the duct and find its way up into the house. To prevent this a series of baffle plates can be built in the air duct as shown by Fig. 7, so that the air will be sifted before it passes into the furnace. These baffles should be made of coarse cheese-cloth and cover about two-thirds of the duct as shown.

The frames of the baffles as A–I are made to slide into grooves so they can be withdrawn at any time and the dust which they have gathered brushed off. This arrangement keeps the air clean and fresh.

Pipes and Registers. — In house heating, the size of the warm air pipe to use for any room depends upon conditions; that is, the construction of the building, exposure, wall and glass surface, length of the warm air pipes, elevation of the same, etc.; under ordinary conditions, however, one square inch of pipe area will heat twenty-five cubic feet in a first floor living room, thirty cubic feet in a second floor sleeping room and fifteen cubic feet in a bath room, if but one side of the room is exposed. Roughly estimating this will give the following table:

Use pipe 8 inches in diameter for rooms containing 1,000 cubic feet.

Use pipe 9 inches in diameter for rooms containing 1,500 cubic feet.

Use pipe 10 inches in diameter for rooms containing 2,000 cubic feet.

Use pipe 12 inches in diameter for rooms containing 3,000 cubic feet.

Use pipe 14 inches in diameter for rooms containing 4,000 cubic feet.

Use pipe 16 inches in diameter for rooms containing 5,000 cubic feet.

For the second floor rooms use one size smaller pipe than for the first floor rooms, as sleeping rooms are not heated to as high a temperature as living rooms. For rooms with two exposed sides use pipe one size larger, also when pipes are unusually long with many bends use one size larger than given in the table. For the heating capacity of pipes see table on page 151.

All warm air pipes should have a damper near the furnace to

regulate the supply of warm air or to shut it off when not in use.

In running the conducting pipes from the furnace give them as much of an angle of elevation as possible, as the only power that moves the warm air through the pipes is its tendency to

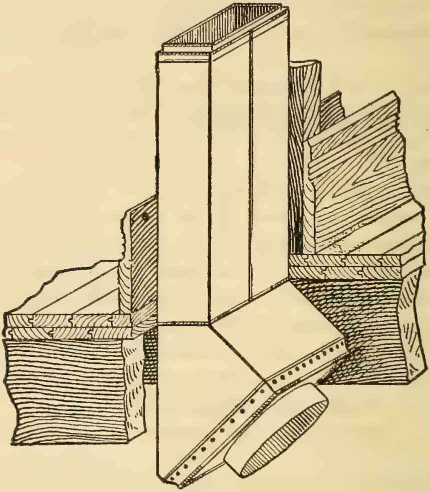


Fig. 8. Riser Shoe Angle Inlet.

rise, hence the greater elevation to the pipes, the greater the velocity of the air.

The pipes should be run as direct as possible and with few bends and no square turns. The bottom of each riser should be provided with a shoe to connect to the heater pipe. In no case should the riser pipe be extended down and a bottom put on and the heater pipe connected by means of a collar on the side of the riser. This is often done but is very poor practice, for the sharp turn will always retard the flow of air.

Shoes should always be provided as shown by Figs. 8 and 9.

Fig. 10 shows a shoe that is both efficient and inexpensive; it was originally designed by C. De Witt Wagner, Cedar Rapids, Ia. A general view is shown at 1, while 2 and 3 are side elevations, 3 having the inlet at an angle; 4 and 5 are end elevations,

4 having the outlet over the center of the shoe, and 5 having the outlet at the side; 6 shows the pattern or layout for the main part of the shoe.

It will be seen that a shoe of this type presents very little friction to the air passing from a round horizontal pipe into a vertical rectangular one.

When one riser supplies two registers as shown by Figs. 11 and 12, there should be a partition in the Tee or pipe as shown at *A*

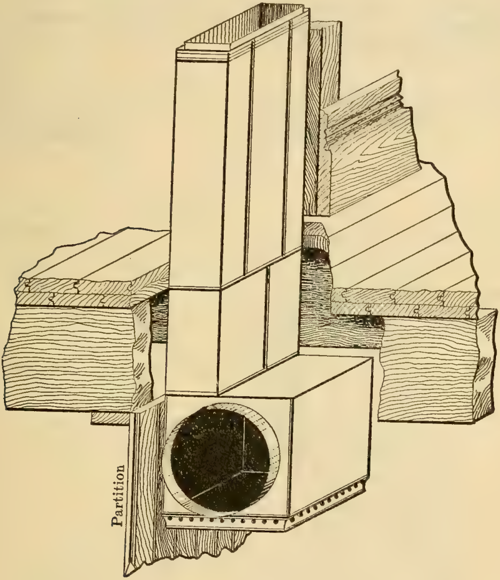


Fig. 9. Riser Shoe Square Inlet.

to divide the air supply, otherwise one register may get more than its share of the warm air, or if in the case of two registers, as shown by Fig. 12, both are open at the same time, there is danger of a circulation from the one room to the other and one room will get all the heat.

Registers are now manufactured with an adjustable damper as shown by Fig. 13. These are excellent for use where one riser supplies several outlets. As shown the damper opens inward and cuts out any desired supply of the warm air.

Great care should be used to see that all the warm air pipes are put in at the proper location and the openings put in at the proper height. When the opening for a wall register is at the bottom it should be just above the base of the room, unless a special make of register is used when it may be set down to the floor line.

In some cases the warm air supply is brought into the room

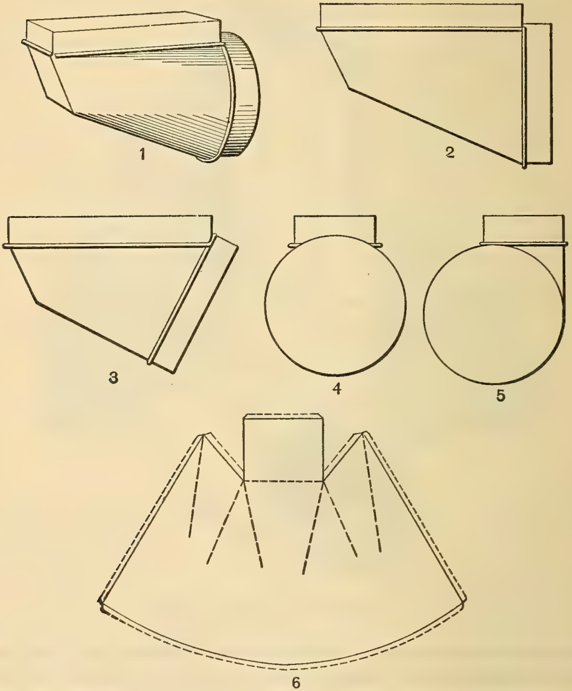


Fig. 10. The Wagner Riser Shoe.

near the ceiling, and in such cases the register openings should be placed about a foot below the ceiling.

The warm air or register opening being placed at different heights according to the system of heating employed, the heights should always be marked or indicated on the drawings.

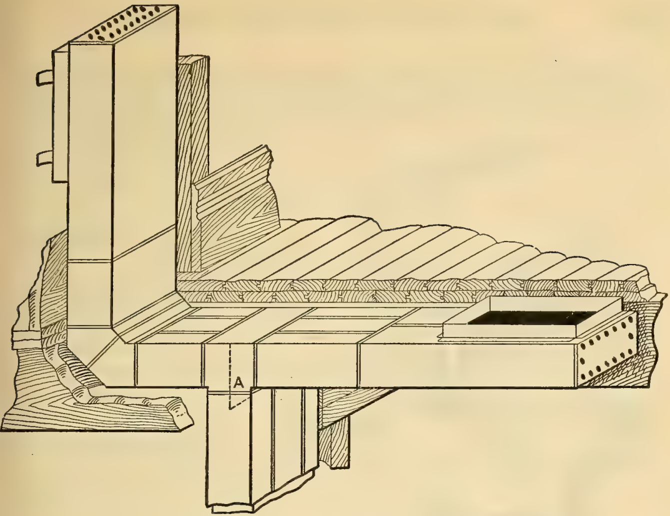


Fig. 11. Partition in Stack Supplying Two Registers.

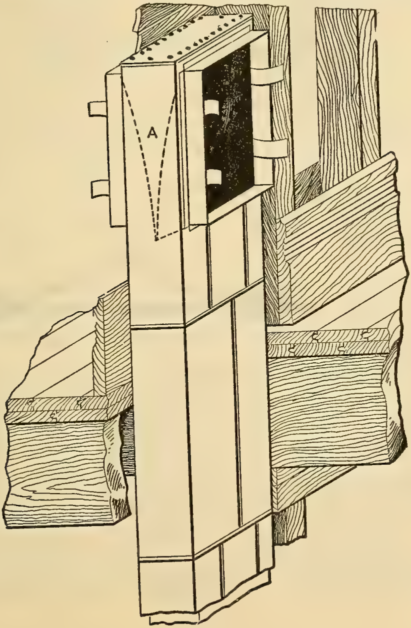


Fig. 12. Partition in Stack Supplying Two Registers.

When air ducts or large rectangular register pipes are used they should be reinforced to prevent them from collapsing, by having ribs of metal, as shown by Fig. 14, riveted across them about every two feet, or have braces riveted in them as shown by Fig. 15.

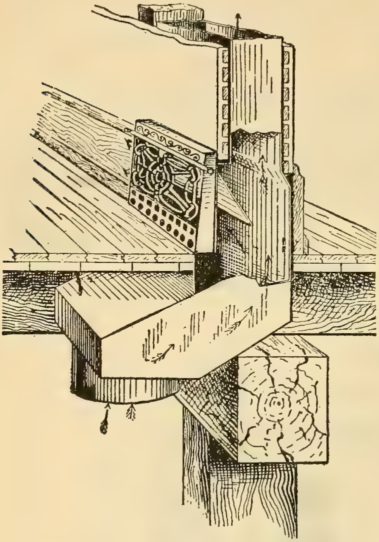


Fig. 13. Improved Register with Damper.

All pipes for conducting warm air should be made of bright tin plate, and where they are enclosed in walls they should be double, with an air space between, to insure from fire, and also prevent the heat from escaping.

All the exposed warm air pipes should be covered with asbestos or wrapped with asbestos paper at least one-half inch in thickness. The common method of wrapping the pipes with a sheet of thin asbestos paper is useless as there is not body enough to the asbestos to do any good as a non-conductor.

Fig. 14. Reinforcing Rib.

Flues. — A faulty chimney flue is very often the cause of much trouble and annoyance. The flue for a furnace should not be less than 8 × 12, when soft coal or wood is used. The flue should be straight and be extended two or three feet below the entrance of the smoke pipe, and have a cleanout door so that the falling soot can be cleaned out at any time.

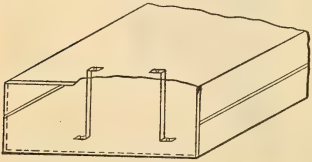


Fig. 15. Braces in Air Ducts.

Another important feature is the height of the chimney. It should not be less than four feet above the highest part of the roof, and if surrounded by high buildings or trees it may be necessary to extend it still higher.

STEAM HEATING.

Steam Heating. — There are two systems of heating by steam, the high pressure and the low pressure systems.

A steam heating system that is to work under a pressure of over 10 pounds is called a high pressure system, and one that is

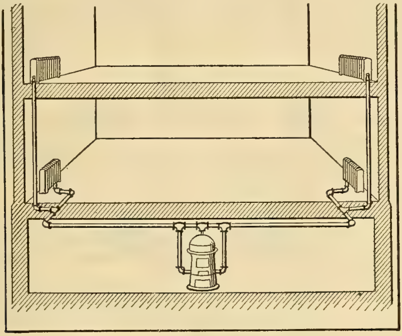


Fig. 16. One Pipe Single System.

to work under a pressure of 10 pounds or less is called a low pressure system.

There are two methods of piping for steam heating, known as The Single Pipe and The Double Pipe or Return Systems.

In the one pipe single system, Fig. 16, the supply pipes are so graded that they carry back all condensation to the boiler direct.

When the condensation is carried direct to the boiler by making a circuit of the building as shown by Fig. 17, it is known as the One Pipe Circuit System, but if the condensation is carried to a return main which is below the water line of the boiler as shown by Fig. 18, then it is known as The One Pipe Relief System.

As the steam in the radiators gives off its heat it condenses, and in the form of water runs back through the risers and branches and returns to the boiler, its place being supplied with

more steam forced into the radiators by the pressure at the boiler.

The water of condensation on reaching the boiler is again converted into steam, and again starts on its journey through the pipes and radiators.

The boiling-point of water is 212 degrees, but in order to force the steam through the radiators a higher temperature is required so as to produce a pressure in the boiler, a 10 pound pressure

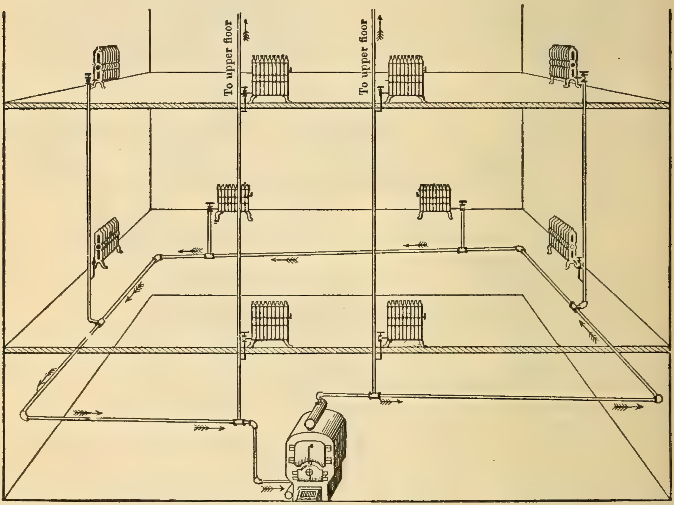


Fig. 17. One Pipe Circuit System.

requiring a temperature of 240 degrees in the water and steam of the boiler.

One Pipe Single System.—In this system, Fig. 16, the main and branches run from the boiler to the radiators giving the pipes as much pitch upward as possible, and the water of condensation is carried back through them to a point near the boiler where a relief pipe should be placed to carry the water to the return opening in the boiler. This system is adapted to small jobs only.

One Pipe Circuit System. In the One Pipe Circuit System shown by Fig. 17, the steam main is taken from the top of the

boiler and run to or as near to the ceiling of the basement as possible, and then with considerable pitch downward (this pitch should not be less than $\frac{1}{2}$ inch in 10 feet) makes an entire circuit

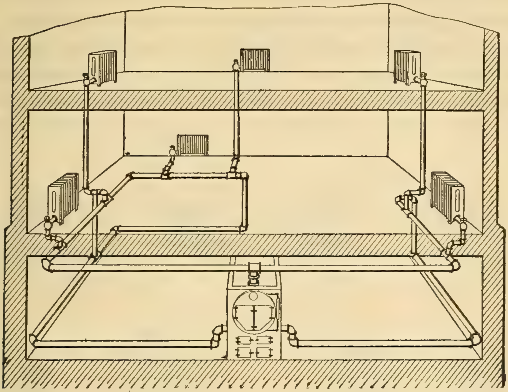


Fig. 18. One Pipe Relief System.

of the building, returning to and connecting with the boiler below the water line.

Single branches and risers are taken from the top of the main and given a grade to bring back all condensation.

The main in this system should be large and of the same size

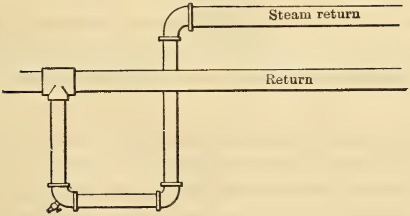


Fig. 19. Seal and Dry Return.

its entire length, and to give good results must have pitch enough to run all condensation back to the boiler.

One Pipe Relief System. — In the One Pipe Relief System, as shown by Fig. 18, the radiators have but one connection,

same as the One Pipe Circuit System, the supply of steam and the returning condensation both using the same pipe.

In this system the main is installed as described for the Circuit System, but the branches and risers are drained into a return main which carries the condensation back to the boiler. When the return main is placed at the floor or below the water line of the boiler it is known as a Wet Return, but if placed overhead or above the water line of the boiler it is known as a Dry Return.

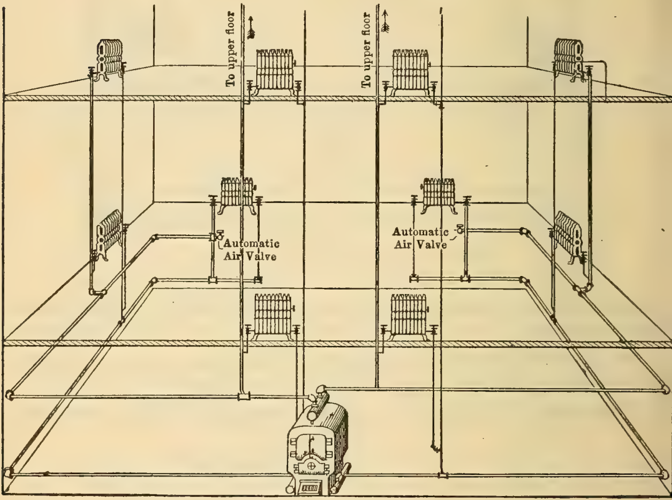


Fig. 20. Two Pipe System of Steam Heating.

Dry returns should be given a greater fall than the wet return, not less than 1 inch to every 10 feet.

The ends of the supply mains and the bottom of all risers should be drained into the return main. If it is a wet return they can be connected direct, but if a dry return the risers should be connected with a syphon as shown by Fig. 19. This loop fills with water and forms a seal which prevents the steam from flowing direct into the return pipe.

If the steam is allowed to flow direct into the overhead return pipe there is likely to be much "cracking" or "hammering"

when the steam comes in contact with the cold water, especially when heat is first turned on.

Two Pipe System. — In the two pipe system of steam heating as shown by Fig. 20, the main risers are taken from the boiler as previously described for the one pipe circuit system, but the supply of steam is carried through the radiators and returned through a separate line of pipe to the boiler.

The main may be reduced in size as branches are taken off, not, however, in proportion to their areas, but very much slower,

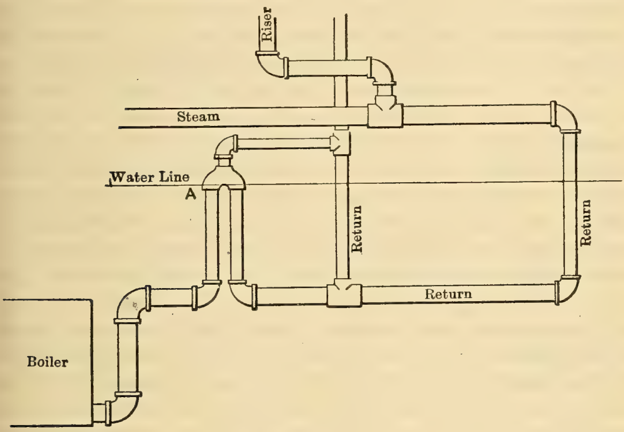


Fig. 21. False Water Line in Return.

and should pass beyond the last branch a foot or more before dropping to the return.

The return starting beyond the last branch should drop below the water line of the boiler and then pitch toward the boiler at least 1 inch in 10 feet; this return should be increased in size as connections are made to it, keeping it about one size less than the steam supply main.

In case the boiler sets in a pit or too low to get the return below the water line of the boiler, a false water line can be established as shown by Fig. 21. As will be seen the return main has to fill with water to the point *A* before it can pass over the loop to the boiler.

THE VACUUM SYSTEM OF STEAM HEATING.—In this system a mechanical apparatus or set of valves are used to keep the air expelled from the system, and as the steam cools or condenses in the radiators a vacuum is created which causes a suction which will draw live steam from the boiler. The following description or explanation of a vacuum system is given by the Norwall Mfg. Co., manufacturers of automatic air valves.

The term "Vacuum" signifies empty space or space void of matter. In practical use it refers to an enclosed space from which the air or other gas has been almost entirely removed. The removal or exhaustion of the air from an enclosed space can be accomplished either by means of a pump, or by condensation of steam. In the Vacuum System of Steam Heating it is condensation of steam that causes the vacuum. Steam is water in a gaseous state occupying a space about seventeen hundred times as great as the water from which it originates, or, in other words, a cubic inch of water when converted into steam, if unconfined, occupies a space equal to about seventeen hundred cubic inches, or about one cubic foot. When the conversion of water into steam takes place within an enclosed space, for instance, a steam heating apparatus (meaning by the term "apparatus" the boiler, connecting pipes, radiators, etc.), if the different parts of the apparatus are properly proportioned, the steam would fill the space in the apparatus not occupied by water were it not for the fact that this apparently unoccupied space is in reality fully occupied by air. When steam is heated above 212° Fahr. within an enclosed space, its expansion is about five times as great as air under similar conditions. Knowing this, it is apparent that air, even though heated to an equal temperature, is a much denser and heavier gas than steam, but when steam is generated in a steam heating apparatus, when the radiators, etc., are cold, the apparatus is full of cold air, and therefore the density of the air is much greater than if it were hot. The two gases, i.e., steam and air, being of different density, will not mix, and the result is when steam is generated there is simply a pushing or a compressing of the air in the pipes and radiators, as the steam pressure increases. In order to allow the steam to circulate into and through the pipe and radiators, it is therefore *absolutely necessary* to provide an outlet for the air, or what is commonly called an *air valve* or *vent* on each and every radiator or heating coil connected with the boiler. When the air has been entirely

expelled from the apparatus by the pressure of steam the apparatus may be said to be full of steam. Since steam occupies a space about seventeen hundred times greater than the water from which it originates, it follows as a natural sequence that the water from which the steam originated occupies a space seventeen hundred times less than the steam; hence, when the steam is again condensed to water the space occupied by the steam will be left a void or vacuum, provided the air is prevented from returning into the system. If the condensation of steam to water were instantaneous, there would be little to recommend the vacuum system of steam heating, but the fact is that the condensation is gradual and can be checked and held at any point desired between atmosphere pressure and absolute vacuum, by simply increasing the strength of the fire.

While the fact is not generally known, it is a fact nevertheless that water will boil and generate steam in absolute vacuum at a temperature of 98° Fahr. At the sea level the atmosphere exerts a pressure of 14.7 lbs. per sq. in., and water boils and generates steam under this pressure at 212° Fahr. As vacuum increases the weight of the atmosphere decreases at the rate of about one pound for every two inches increase in vacuum, and because of this decrease in the weight or pressure of the atmosphere, water boils and generates steam at a lower and lower temperature until absolute vacuum and a boiling temperature of 98 degrees is reached, which is the lowest temperature at which water can be made to boil and generate steam.

The measure of vacuum is in inches, and if accuracy is desired a mercury gauge is used. A common form of this gauge consists of an inverted graduated syphon of glass, like the letter "U," open at one end to the atmosphere and the other end connected with the apparatus to be tested, and containing a quantity of mercury. When not in use, the mercury rises equally in both legs of this syphon. On connecting the instrument with a vacuum the mercury rises in the leg connected with the apparatus and falls in the other leg, the difference in inches between them being the measure of vacuum. With absolute vacuum, the difference between the two columns is 28.92 inches with a boiling temperature of 98 degrees, while "O" represents pressure in apparatus equal to atmosphere, and a boiling temperature of 212 degrees. The different points between these two extremes indicate the various degrees of vacuum and the boiling tempera-

tures of water, and the boiling temperature of water at the various degrees is shown in the following table:

Inches of Vacuum.	Temperature at which Water Boils.	Inches of Vacuum.	Temperature at which Water Boils.
	Degrees.		Degrees.
0	212	16	175.8
1	210.3	17	172.6
2	208.5	18	169
3	206.8	19	165.3
4	204.8	20	161.2
5	202.9	21	156.7
6	200.9	22	151.9
7	199	23	146.5
8	196.7	24	140.3
9	194.5	25	133.3
10	192.2	26	124.9
11	189.7	27	114.4
12	187.3	28	108.4
13	184.6	29	102
14	181.3	29.92	98
15	178.9		

HOT WATER HEATING.

Hot Water Heating. — The hot water system has pipes and radiators similar to the steam heating system, but instead of using the steam from the hot water, the water itself is used to fill the pipes and radiators to a point in the expansion tank higher than the highest radiator.

The circulation of the water to the radiators and back to the boiler is caused by the difference in weight between cold and hot water.

When the water is heated it expands, and as it increases in bulk but not in weight it becomes relatively lighter than the cold water in the return pipes and hence rises to the highest point in the system.

As the water cools it becomes heavier and falls back through the return pipes to the boiler, to be reheated and returned to the radiators.

This action of the hot water ascending and the cold water descending is what makes the circulation in a hot water system, and this action will continue as long as the water in the boiler is hotter than that in the return pipes.

Direct Hot Water Heating. — Fig. 22 illustrates a system of hot water heating. In this system the water flows from the

boiler through the supply pipes, passes through the radiators and is returned to the boiler through the return pipes as indicated.

The water is continually in circulation caused by the water in the supply pipes being hotter than that in the return. Thus the hot water rises and the cool water descends back through the return pipes to the boiler.

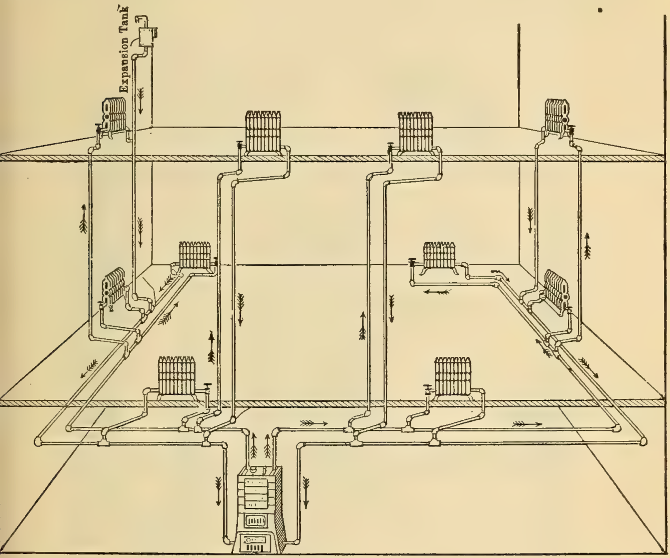


Fig. 22. Direct Hot Water Heating.

In this system the main or mains rise from the boiler only sufficiently to permit the flow main to rise at least 1 inch in 10 feet or more if possible to the last connection. The main can be reduced as branches are taken off.

The return main should run practically parallel to the flow or supply main and should increase as connections are made to it. The mains at any point should have an area equal to the area of all branches or risers beyond that point.

The expansion tank can be connected to the return at any point, or it may be connected to the boiler independently.

Overhead Feed System of Hot Water Heating. — In the overhead system of hot water heating as shown by Fig. 23, the flow or supply main is carried direct to the attic or to the highest point to be heated, at which point the expansion tank should be located, thence either in a circuit or by branches downward at least 1 inch in 10 feet to a point over the radiators, then down to the cellar, taking from the return riser connections to the top and bottom of the radiators as shown.

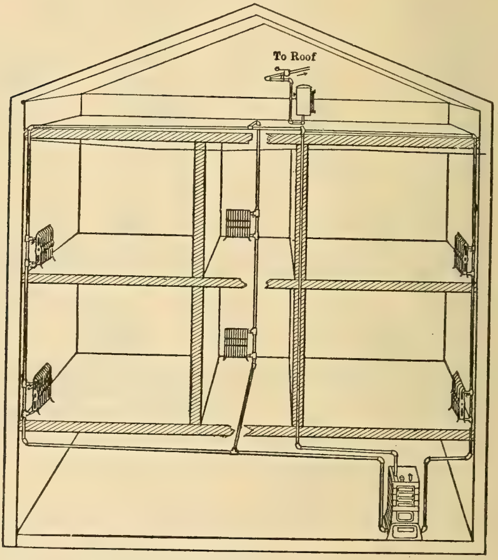


Fig. 23. Overhead Feed System of Hot Water Heating.

The main may be reduced as branches are taken off, but the return risers should be the same size from top to bottom.

The expansion tank should have a safety valve set at about 10 pounds.

Indirect Steam or Hot Water Heating. — An indirect system of steam or hot water heating is one where the radiators are installed in a box or chamber in the basement of the building, and cold air from the outside is brought in and circulated around the radiators. This air becomes warm and ascends through the

warm air pipes to heat the house similarly to the furnace system, as shown by Fig. 24.

All indirect heating should be in connection with some system of ventilation, and therefore a larger volume of air must be warmed than when using the direct radiation. When figuring

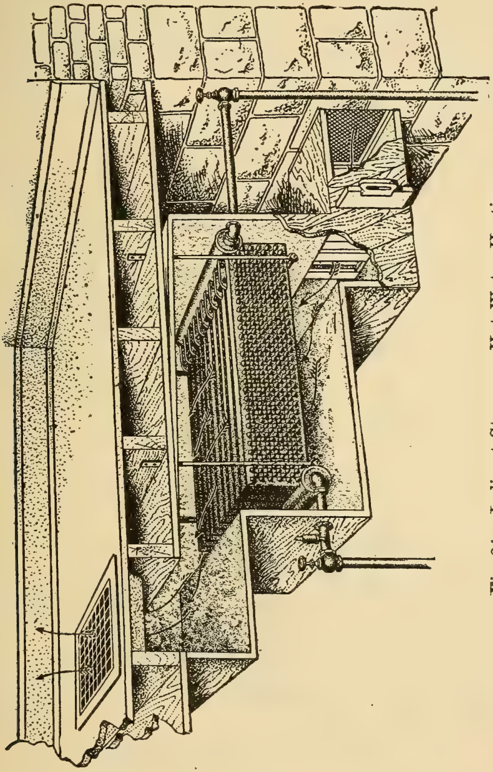


Fig. 24. Indirect Steam or Hot Water Heating.

indirect radiation surface, due allowance must be made for this excess of air and the same provided for by increasing the amount of radiating surface.

In hot water indirect work it is not good policy to supply more than 100 feet of radiation from one connection. When require-

ments are for larger stacks they should be divided into two or more according to their size.

Direct-Indirect Heating. — This method of heating is shown by Fig. 25. The radiators are set as usual and a supply of air from the outside is obtained and circulated around and through the radiator as shown. This air becomes heated and circulates through the room giving a supply of fresh warm air. When this system is used there must be sufficient radiating surface to heat the extra supply of cold air being brought in as explained under indirect heating.

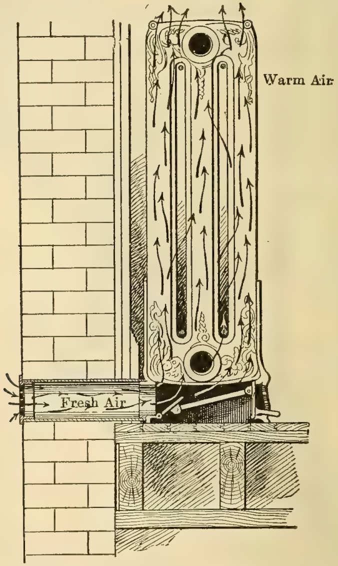


Fig. 25. Direct-Indirect Heating.

MISCELLANEOUS HEATING DATA.

When the "roughing in" of a heating system is being done, all the radiator connections, and all Tee or branch outlets should

be plugged or capped as soon as put in place to prevent any dirt from getting in the pipe and possibly damaging the valves.

In running all pipes care must be taken to provide for expansion and contraction, and suitable provision made so there will be no danger of breaking a pipe or connection.

After the piping is all in place it should be tested before being covered up; this should be done by filling the pipes full of water and applying pressure with a force-pump to 100 or 150 pounds, then if possible a steam test should be made before covering the pipes.

All hot-water or steam pipes should be kept clear of all woodwork or other combustible material by about 4 inches.

Pressure of Systems.—The high-pressure system is applied with steam at any pressure over 10 pounds.

The low-pressure system is operated with a pressure of from 2 to 5 pounds.

Location of Radiators.—Radiators should always be placed at outside walls, and near or under the window, so as to counteract the entrance of the cold air at the window. This will give a more even temperature in the room than if the radiator were located at the other side of the room.

In piping for a hot-water system all bends and angles should be made as easy as possible so as to prevent friction.

DATA FOR HOT-WATER HEATING.

Table of Ratios.

Dwellings.	One Square Foot of Radiating Surface will Heat
Living-rooms, one side exposed	30 cubic feet.
" , two sides exposed	28 " "
" , three sides exposed	28 " "
Sleeping-room	From 30 to 40 " "
Hall-room	" 20 " 30 " "
Bath-room	" 20 " 30 " "
Public Buildings.	
School-rooms	" 30 " 50 " "
Offices	" 30 " 50 " "
Factories	" 50 " 70 " "
Stores	" 50 " 70 " "
Auditoriums	" 80 " 100 " "
Churches	" 80 " 100 " "

DATA FOR STEAM HEATING.

TABLE OF RATIOS.

Dwellings.	One Square Foot of Radiating Surface will Heat			
Living-rooms, one side exposed	From	45 to 50	cubic	feet.
" " two sides exposed	"	45 to 45	"	"
" " three sides exposed	"	35 to 45	"	"
Sleeping-rooms	"	50 to 70	"	"
Halls and bathrooms	"	40 to 50	"	"
Public Buildings.				
School-rooms	"	60 to 80	"	"
Offices	"	50 to 75	"	"
Factories and stores	"	70 to 100	"	"
Auditoriums and churches	"	80 to 100	"	"

The above ratios are for direct heating and an average temperature of 168° F. in the water.

Hot Water. — For direct-indirect radiation add $33\frac{1}{3}$ per cent, and for indirect radiation add 75 per cent, to the amount of direct surface required in the above table.

Steam. — For direct-indirect radiation add 25 per cent, and for indirect radiation add 50 per cent, to the amount of direct surface required in the above tables.

Due care must be exercised to provide for any special conditions, such as exposure of buildings, material of construction, location and length and size of mains governing plant under consideration.

Allowances should also be made for loose construction of doors and windows, which admit large volumes of cold air, and provide for outside doors which are used frequently and open directly into the room.

In estimating the radiating surface, it should be borne in mind that a large surface at a comparatively low temperature gives a much pleasanter atmosphere than a small surface at a high temperature.

APPROXIMATES.

ADD $33\frac{1}{3}$ per cent to water rating for tank rating.
DEDUCT 25 per cent from tank rating for water rating.
ADD 65 per cent to steam rating for water rating.
DEDUCT 40 per cent from water rating for steam rating.

Under normal market conditions Hot Water Heating installation costs about 30 per cent more than steam, but steam heating costs to operate about 20 per cent more than hot water.

Under favorable conditions one square inch of grate is sufficient for one square foot of direct steam radiation in medium sized heaters, which radiation may be increased in larger and reduced in smaller heaters.

Divide the area of the grate by 8 to 10 for area of flue. No flue should be less than 8 × 8 or 8 inches round.

GREENHOUSE AND CONSERVATORY HEATING.

The following ratios of heating surface have been found to give good results in figuring the heating surface for greenhouses and conservatories. The ratios are to be used considering the outside temperature to be 0° F.

PROPORTION OF GLASS TO HEATING SURFACE.

	Steam.	Hot Water.
For 45° inside temperature, divide the total glass surface by	8	5
For 50° inside temperature, divide the total glass surface by	7	4.5
For 55° inside temperature, divide the total glass surface by	6.5	4
For 60° inside temperature, divide the total glass surface by	6	3.5
For 65° inside temperature, divide the total glass surface by	5	3.25
For 70° inside temperature, divide the total glass surface by	4.5	3

BRANCHES WHICH A GIVEN MAIN WILL SUPPLY.

The following table on page 28 gives the number of various size branches which a given main will supply, or the size of main to use for a number of different size branches.

Example. — To find the branches which a 6″ main will supply turn to the table and in the column of mains find 6″, and following the lines under branches we find that a 6″ main will supply either one 5″ and one 4″ branch or two 4″ and one 3″ or four 3″ or ten 2″.

APPROXIMATE NUMBER AND SIZE OF BRANCHES SUPPLIED FROM A GIVEN MAIN.

Main.	Branches.								
	5″	4″	3½″	3″	2½″	2″	1½″	1¼″	1″
6″	1	1							
	or	2		1					
	or			4					
						10			
5″		2							
	or		2			1			
	or			3					
						7			
4″				2					
	or		1		1				
	or					4			
3½″				1		1			
	or				2				
	or					3			
3″					1	1			
	or					2		1	
	or						4		
2½″						1	1		
	or						3		
	or							4	
2″							2		
	or						1	2	
1½″								2	
	or							1	2
1¼″									2

Comparative Pipe Areas. — Doubling the diameter of a pipe increases its capacity four times.

AREA OF DUCTS FOR INDIRECT HEATING.

The common practice is to make the area of the cold-air duct in case of steam $1\frac{1}{2}$ inches for each square foot of surface in the radiator. For water, 1 inch. The warm-air flue areas for steam, 2 inches for first floor; $1\frac{1}{2}$ inches for second floor. For water, $1\frac{1}{2}$ inches for first floor; 1 inch for second floor.

HEATING BY PIPE COILS. — To ascertain the lineal feet of pipe to use when heating by pipe coils, multiply the square feet of heating surface required as follows:

For 1-inch pipe multiply heating surface by 3.
For $1\frac{1}{4}$-inch pipe multiply heating surface by 2.3.
For $1\frac{1}{2}$-inch pipe multiply heating surface by 2.
For 2-inch pipe multiply heating surface by 1.6.

PRESSURE OF WATER.

The pressure of water per square inch is one pound for every 28 inches in height of water column.

PRESSURE PER SQUARE INCH ON BOILER.

To find the pressure on a hot water boiler, multiply height in feet of water line at the expansion tank above the boiler by .434; the result will be in pounds to the square inch.

PRESSURE OF WATER FOR EACH FOOT IN HEIGHT.

Feet in Height.	Lbs. per Sq. In.	Feet in Height.	Lbs. per Sq. In.	Feet in Height.	Lbs. per Sq. In.
1	.43	15	6.49	50	21.65
2	.86	20	8.66	70	30.32
5	2.16	25	10.82	80	34.65
10	4.33	40	17.32	100	43.31

APPROXIMATE NUMBER OF CUBIC FEET OF AIR ONE SQUARE FOOT OF RADIATION WILL HEAT. (NASON.)

One Square Foot of Radiating Surface will Heat with	In Dwellings, Schoolrooms, Offices, etc. Cubic Feet.	In Halls, Stores, Lofts, Factories, etc. Cubic Feet.	In Churches, Large Auditoriums, etc. Cubic Feet.
Direct-steam radiation........	60 to 80	75 to 100	150 to 200
Indirect-steam radiation.......	40 to 50	50 to 70	100 to 140
High temperature, direct hot-water radiation.............	50 to 70	65 to 90	130 to 180
Low temperature, direct hot-water radiation.............	30 to 50	35 to 65	70 to 130
High temperature, indirect hot-water radiation.............	30 to 60	35 to 75	70 to 150
Low temperature, indirect hot-water radiation.............	20 to 40	25 to 50	50 to 100

The above proportions will give a temperature in the buildings described of 70° F., the thermometer being at zero in the outside atmosphere.

While there is no iron-clad rule for computing the proper amount of radiation for heating buildings, owing to the variable conditions that enter into the calculation, the above table will prove valuable if allowances are made for extreme cases.

It is well to remember that small rooms, rooms with large window surfaces or exposed sides, and rooms with exceptionally thick walls or fireproof tiling require more radiating surface in proportion to space than is ordinarily needed. Frame buildings require more radiation than stone, and stone more than brick.

A good method for computing the amount of radiation required is the "2–20–200 rule" as follows: — Allow 1 square foot of radiation for every 200 cubic feet of space in the room, 1 square foot of radiation for every 20 square feet of exposed wall surface and 1 square foot of radiation for every 2 square feet of glass in the walls of the room.

This will give the required amount of steam radiation, which should be increased 60 per cent for hot water.

The Plumbers Trade Journal, New York, in a serial by C. B. Thompson, recently gave the following rule and tables for computing radiation, and which is claimed will give a more even distribution of radiation than the 2–20–200 rule.

Rule. — Divide the glass or window openings, including the sash, by 2, and the exposed wall, after the window openings have been deducted, by 10. This is for 70 degrees temperature difference only; that is, external zero, internal 70 degrees.

The table on page 32 shows the quantity of steam radiation required to heat any given room, when the square feet of glass and square feet of exposed wall are known. *Example:* Suppose a given room contains 60 square feet of glass and 340 square feet of exposed wall; that is, net wall after the window openings have been deducted. Look for 60 in the left-hand vertical column, and 340 on the horizontal upper line, and where the two lines intersect read 64 square.

SQUARE FEET OF RADIATING SURFACE OF PIPE PER LINEAL FOOT.

On all lengths over one foot, fractions less than tenths are added to or dropped.

Length of Pipe.	Size of Pipe.											
	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	4	5	6	7	8
1	.275	.346	.434	.494	.622	.753	.916	1.175	1.455	1.739	1.996	2.257
2	.5	.7	.9	1.	1.2	1.5	1.8	2.4	2.9	3.5	4.	4.5
3	.8	1.	1.3	1.5	1.9	2.3	2.7	3.5	4.4	5.2	6.	6.8
4	1.1	1.4	1.7	2.	2.5	3.	3.6	4.7	5.8	7.	8.	9.
5	1.4	1.7	2.2	2.4	3.1	3.8	4.6	5.8	7.3	7.7	10.	11.3
6	1.6	2.1	2.6	2.9	3.7	4.5	5.5	7.	8.7	10.5	12.	13.5
7	1.9	2.4	3.	3.4	4.4	5.3	6.4	8.2	10.2	12.1	14.	15.8
8	2.2	2.8	3.5	3.9	5.	6.	7.3	9.4	11.6	13.9	16.	18.
9	2.5	3.1	3.9	4.4	5.6	6.8	8.2	10.6	13.1	15.7	18.	20.3
10	2.7	3.5	4.3	4.9	6.2	7.5	9.1	11.8	14.6	17.4	20.	22.6
11	3.	3.8	4.8	5.4	6.8	8.3	10.	12.9	16.	19.1	22.	24.9
12	3.3	4.1	5.2	5.9	7.5	9.	11.	14.1	17.4	20.9	24.	27.1
13	3.6	4.5	5.6	6.4	8.1	9.8	11.9	15.3	18.9	22.6	26.	29.4
14	3.8	4.8	6.1	6.9	8.7	10.5	12.8	16.5	20.3	24.3	28.	31.6
15	4.1	5.2	6.5	7.4	9.3	11.3	13.7	17.6	21.8	26.1	30.	33.9
16	4.4	5.5	6.9	7.9	10.	12.	14.6	18.8	23.2	27.8	32.	36.1
17	4.7	5.9	7.4	8.4	10.6	12.8	15.5	20.	24.7	29.5	34.	38.4
18	5.	6.2	7.8	8.9	11.2	13.5	16.5	21.2	26.2	31.3	36.	40.6
19	5.2	6.6	8.3	9.4	11.8	14.3	17.4	22.3	27.6	33.1	38.	42.9
20	5.5	6.9	8.7	9.9	12.5	15.	18.3	23.5	29.1	34.8	40.	45.2
21	5.8	7.3	9.1	10.4	13.	15.8	19.2	24.7	30.5	36.5	42.	47.4
22	6.	7.6	9.6	10.9	13.7	16.5	20.2	25.9	32.	38.3	44.	49.7
23	6.3	8.	10.	11.3	14.3	17.3	21.1	27.	33.5	40.	46.	52.
24	6.6	8.3	10.4	11.9	14.9	18.	22.	28.2	34.9	41.7	48.	54.2
25	6.9	8.6	10.9	12.3	15.6	18.8	22.9	29.3	36.3	43.5	50.	56.4
26	7.1	9.	11.3	12.8	16.2	19.5	23.8	30.5	37.8	45.2	52.	58.6
27	7.4	9.4	11.7	13.3	16.8	20.3	24.7	31.7	39.3	47.	54.	61.
28	7.7	9.7	12.2	13.8	17.4	21.	25.6	32.9	40.7	48.7	56.	63.2
29	8.	10.	12.6	14.3	18.	21.8	26.6	34.1	42.2	50.4	58.	65.5
30	8.3	10.4	13.	14.8	18.7	22.5	27.5	35.3	43.6	52.1	60.	67.7
31	8.5	10.7	13.5	15.3	19.3	23.3	28.4	36.4	45.1	53.9	62.	70.
32	8.8	11.1	13.9	15.8	19.9	24.1	29.3	37.6	46.5	55.6	64.	72.2
33	9.1	11.4	14.3	16.3	20.5	24.8	30.2	38.8	48.	57.4	66.	74.4
34	9.4	11.7	14.7	16.8	21.2	25.6	31.1	40.	49.5	59.1	68.	76.7
35	9.6	12.1	15.2	17.3	21.8	26.3	32.	41.1	50.9	60.8	70.	79.
36	9.9	12.5	15.6	17.8	22.4	27.	33.	42.3	52.4	62.6	72.	81.3
37	10.2	12.8	16.1	18.3	23.	27.8	33.9	43.5	53.8	64.3	74.	83.5
38	10.5	13.2	16.5	18.8	23.7	28.5	34.8	44.6	55.2	66.	76.	85.8
39	10.7	13.5	16.9	19.3	24.3	29.3	35.7	45.8	56.7	67.8	78.	88.
40	11.	13.8	17.4	19.8	24.9	30.1	36.6	47.	58.2	69.5	80.	90.2
41	11.3	14.2	17.8	20.3	25.5	30.8	37.6	48.2	59.6	71.3	82.	92.5
42	11.5	14.5	18.2	20.8	26.1	31.6	38.5	49.4	61.1	73.	84.	94.8
43	11.8	14.9	18.7	21.3	26.8	32.3	39.4	50.6	62.5	74.8	86.	97.
44	12.1	15.2	19.1	21.8	27.4	33.1	40.3	51.7	64.	76.5	88.	99.3
45	12.4	15.6	19.5	22.2	28.	33.8	41.2	52.9	65.5	78.2	90.	101.6
46	12.7	15.9	20.0	22.7	28.6	34.6	42.2	54.	67.	80.0	92.	103.8
47	12.9	16.3	20.4	23.2	29.2	35.3	43.	55.2	68.4	81.7	94.	106.
48	13.2	16.6	20.8	23.7	29.9	36.1	43.9	56.4	69.8	83.5	96.	108.4
49	13.5	17.	21.3	24.2	30.5	36.8	44.8	57.6	71.2	85.1	98.	110.5
50	13.8	17.3	21.7	24.7	31.1	37.6	45.8	58.7	72.7	87.	100.	112.8

TABLE SHOWING SQUARE FEET OF RADIATION (STEAM) REQUIRED.

Steam at 2 Pounds.
Outside Temperature at 0° F.
Inside Temperature at 70° F.

Square Feet of Glass Surface (Including Sash) \ Square Feet of Exposed Wall	0	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500
0	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
5	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53
10	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55
15	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58
20	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60
25	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63
30	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65
35	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68
40	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
45	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73
50	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73	75
55	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78
60	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80
65	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73	75	77	79	81	83
70	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73	75	77	79	81	83	85
75	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
80	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90
85	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73	75	77	79	81	83	85	87	89	91	93
90	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73	75	77	79	81	83	85	87	89	91	93	95
95	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98
100	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
105	53	55	57	59	61	63	65	67	69	71	73	75	77	79	81	83	85	87	89	91	93	95	97	99	101	103
110	55	57	59	61	63	65	67	69	71	73	75	77	79	81	83	85	87	89	91	93	95	97	99	101	103	105
115	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108
120	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
125	63	65	67	69	71	73	75	77	79	81	83	85	87	89	91	93	95	97	99	101	103	105	107	109	111	113
130	65	67	69	71	73	75	77	79	81	83	85	87	89	91	93	95	97	99	101	103	105	107	109	111	113	115
135	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118
140	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120
145	73	75	77	79	81	83	85	87	89	91	93	95	97	99	101	103	105	107	109	111	113	115	117	119	121	123
150	75	77	79	81	83	85	87	89	91	93	95	97	99	101	103	105	107	109	111	113	115	117	119	121	123	125
155	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120	122	124	126	128
160	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120	122	124	126	128	130

TABLE SHOWING SQUARE FEET OF RADIATION (WATER) REQUIRED.

Radiator at 170° F.
Outside Temperature at 0°F.
Inside Temperature at 70° F.

Square Feet of Exposed Wall (columns); Square Feet of Glass Surface (Including Sash) (rows)

Glass \ Wall	0	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500
0	0	3	6	10	13	16	19	22	26	29	32	35	38	42	45	48	51	54	58	61	64	67	70	74	77	80
5	4	7	10	14	17	20	23	26	30	33	36	39	42	46	49	52	55	58	62	65	68	71	74	78	81	84
10	8	11	14	18	21	24	27	30	34	37	40	43	46	50	53	56	59	62	66	69	72	75	78	82	85	88
15	12	15	18	22	25	28	31	34	38	41	44	47	50	54	57	60	63	66	70	73	76	79	82	86	89	92
20	16	19	22	26	29	32	35	38	42	45	48	51	54	58	61	64	67	70	74	77	80	83	86	90	93	96
25	20	23	26	30	33	36	39	42	46	49	52	55	58	62	65	68	71	74	78	81	84	87	90	94	97	100
30	24	27	30	34	37	40	43	46	50	53	56	59	62	66	69	72	75	78	82	85	88	91	94	98	101	104
35	28	31	34	38	41	44	47	50	54	57	60	63	66	70	73	76	79	82	86	89	92	95	98	102	105	108
40	32	35	38	42	45	48	51	54	58	61	64	67	70	74	77	80	83	86	90	93	96	99	102	106	109	112
45	36	39	42	46	49	52	55	58	62	65	68	71	74	78	81	84	87	90	94	97	100	103	106	110	113	116
50	40	43	46	50	53	56	59	62	66	69	72	75	78	82	85	88	91	94	98	101	104	107	110	114	117	120
55	44	47	50	54	57	60	63	66	70	73	76	79	82	86	89	92	95	98	102	105	108	111	114	118	121	124
60	48	51	54	58	61	64	67	70	74	77	80	83	86	90	93	96	99	102	106	109	112	115	118	122	125	128
65	52	55	58	62	65	68	71	74	78	81	84	87	90	94	97	100	103	106	110	113	116	119	122	126	129	132
70	56	59	62	66	69	72	75	78	82	85	88	91	94	98	101	104	107	110	114	117	120	123	126	130	133	136
75	60	63	66	70	73	76	79	82	86	89	92	95	98	102	105	108	111	114	118	121	124	127	130	134	137	140
80	64	67	70	74	77	80	83	86	90	93	96	99	102	106	109	112	115	118	122	125	128	131	134	138	141	144
85	68	71	74	78	81	84	87	90	94	97	100	103	106	110	113	116	119	122	126	129	132	135	138	142	145	148
90	72	75	78	82	85	88	91	94	98	101	104	107	110	114	117	120	123	126	130	133	136	139	142	146	149	152
95	76	79	82	86	89	92	95	98	102	105	108	111	114	118	121	124	127	130	134	137	140	143	146	150	153	156
100	80	83	86	90	93	96	99	102	106	109	112	115	118	122	125	128	131	134	138	141	144	147	150	154	157	160
105	84	87	90	94	97	100	103	106	110	113	116	119	122	126	129	132	135	138	142	145	148	151	154	158	161	164
110	88	91	94	98	101	104	107	110	114	117	120	123	126	130	133	136	139	142	146	149	152	155	158	162	165	168
115	92	95	98	102	105	108	111	114	118	121	124	127	130	134	137	140	143	146	150	153	156	159	162	166	169	172
120	96	99	102	106	109	112	115	118	122	125	128	131	134	138	141	144	147	150	154	157	160	163	166	170	173	176
125	100	103	106	110	113	116	119	122	126	129	132	135	138	142	145	148	151	154	158	161	164	167	170	174	177	180
130	104	107	110	114	117	120	123	126	130	133	136	139	142	146	149	152	155	158	162	165	168	171	174	178	181	184
135	108	111	114	118	121	124	127	130	134	137	140	143	146	150	153	156	159	162	166	169	172	175	178	182	185	188
140	112	115	118	122	125	128	131	134	138	141	144	147	150	154	157	160	163	166	170	173	176	179	182	186	189	192
145	116	119	122	126	129	132	135	138	142	145	148	151	154	158	161	164	167	170	174	177	180	183	186	190	193	196
150	120	123	126	130	133	136	139	142	146	149	152	155	158	162	165	168	171	174	178	181	184	187	190	194	197	200
155	124	127	130	134	137	140	143	146	150	153	156	159	162	166	169	172	175	178	182	185	188	191	194	198	201	204
160	128	131	134	138	141	144	147	150	154	157	160	163	166	170	173	176	179	182	186	189	192	195	198	202	205	208

The table on page 33 shows the quantity of radiation required for water heating apparatus, when operated under the conditions named in the table. *Example:* A room contains 60 square feet of glass and 340 square feet of wall; how much radiation is required?

Look for the intersection of the lines corresponding to 60 square feet of glass and 340 square feet of wall, and find 102, the quantity of radiation required in square feet. For temperature differences other than 70, multiply figures found in the table by the following factors:

30 degrees temperature difference by	.43
40 degrees temperature difference by	.59
45 degrees temperature difference by	.65
50 degrees temperature difference by	.72
55 degrees temperature difference by	.79
60 degrees temperature difference by	.86
65 degrees temperature difference by	.93
75 degrees temperature difference by	1.08
80 degrees temperature difference by	1.14
90 degrees temperature difference by	1.28
100 degrees temperature difference by	1.43

The following rules regarding heating by steam are given by Babcock & Wilcox:

Heating by Steam. — In heating buildings by steam the amount of boiler and heating pipes depends largely on the kind of building and its location. Wooden buildings require more than stone, and stone more than brick. Iron fronts require still more, and glass in windows demands twenty times as much heat as the same surface in brick walls. Also if the heating be done by indirect radiation from 50 to 100 per cent more surface will be required than when direct radiation is used. No rules can be given which will not require a liberal application of "the coefficient of common sense."

Radiating surface may be calculated by the rule: *Add together the square feet of glass in the windows, the number of cubic feet of air required to be changed per minute, and one-twentieth the*

surface of external wall and roof; multiply this sum by the difference between the required temperature of the room and that of the external air at its lowest point and divide the product by the difference in temperature between the steam in the pipes and the required temperature of the room. The quotient is the required radiating surface in square feet. Each square foot of radiating surface may be depended upon in average practice to give out three heat-units per hour for each degree of difference in temperature between the steam inside and the air outside, the range under different conditions being about 50 per cent above or below that figure. In *indirect* heating the efficiency of the radiating surface will increase, and the temperature of the air will diminish, when the quantity of the air caused to pass through the coil increases. Thus one square foot radiating surface, with steam at 212°, has been found to heat 100 cubic feet of air per hour from zero to 150°, or 300 cubic feet from zero to 100° in the same time.

The best results are attained by using indirect radiation to supply the necessary ventilation, and direct radiation for the balance of the heat. The best place for a radiator in a room is beneath a window. Heated air cannot be made to enter a room unless means are provided for permitting an equal amount to escape. The best place for such exit openings is near the floor.

Small pipes are more effective than large. When the diameter is doubled, 20 per cent additional surface should be allowed, and for three times the diameter 30 per cent additional is required. For indirect radiation that surface is most efficient which secures the most intimate contact of the current of air with the heated surface. Rooms on windward side of house require more radiating surface than those on sheltered side.

Where the condensed water is returned to the boiler, or where low pressure of steam is used, the diameter of mains leading from the boiler to the radiating surface should be equal, in inches, to *one-tenth the square root of the radiating surface, mains included,* in square feet. Thus a 1-inch pipe will supply 100 square feet of surface, itself included. Return pipes should be at least $\frac{3}{4}$ inch in diameter, and never less than one-half the diameter of the main—longer returns requiring larger pipes. A thorough drainage of steam-pipes will effectually prevent all cracking and pounding noises therein.

The amount of air required for ventilation is from 4 to 16 cubic feet per minute for each person, the larger amount being for prisons and hospitals. From $\frac{1}{2}$ to 1 cubic foot per minute should be allowed for each lamp or gas-burner employed.

One square foot of boiler surface will supply from 7 to 10 square feet of radiating surface, depending upon the size of boiler and the efficiency of its surface, as well as that of the radiating surface. Small boilers for house use should be much larger proportionately than large plants. Each horse-power of boiler will supply from 240 to 360 feet of 1-inch steam-pipe, or from 80 to 120 square feet of radiating surface.

Cubic feet of space has little to do with amount of steam or surface required, but is a convenient factor for rough calculations. Under ordinary conditions one horse-power will heat, approximately, in

Brick dwellings, in blocks, as in cities. . .	15,000 to 20,000 cu. ft.
Brick stores, in blocks.	10,000 to 15,000 cu. ft.
Brick dwellings, exposed all round.	10,000 to 15,000 cu. ft.
Brick mills, shops, factories, etc.	7,000 to 10,000 cu. ft.
Wooden dwellings, exposed	7,000 to 10,000 cu. ft.
Foundries and wooden shops.	6,000 to 10,000 cu. ft.
Exhibition buildings, largely glass, etc.	4,000 to 15,000 cu. ft.

The system of heating mills and manufactories by means of pipes placed overhead is being largely adopted, and is recommended by the Boston Manufacturers' Mutual Fire Insurance Company, in preference to radiators near the floor, particularly for rooms in which there are shafting and belting to circulate the air.

In heating buildings care should be taken to supply the necessary moisture to keep the air from becoming "dry" and uncomfortable. The capacity of air for moisture rises rapidly as it is heated, it being four times as great at 72° as at 32°. For comfort, air should be kept at about "50 per cent saturated." This would require one pound of vapor to be added to each 2,500 cubic feet heated from 32° to 70°.

A much-needed attachment has recently been introduced, which acts automatically upon the steam-valves of the radiators, or upon the hot-air registers and ventilators, and maintains the temperature in a room to within one-half a degree of any standard desired.

A "separator" acting by centrifugal force has been recently tested, and is very efficient, in trapping out all the water entrained in steam. It will be found valuable, particularly where the steam has to be carried a long distance from the boiler, and for the purpose of preventing "hammering" of water in the pipes.

Resistance to Flow by Bends, Valves, etc.—Mr. Briggs states in "Warming Buildings by Steam," that the resistance at the entrance to a pipe consists of two parts, namely, the head, $\frac{v^2}{2g}$, which is necessary to create the velocity of flow and the head, $0.505\frac{v^2}{2g}$, which overcomes the resistance to entrance offered by the mouth of the pipe. The total loss of head at entrance then equals the sum of these, or $1.505\frac{v^2}{2g}$, in which v = velocity of flow of steam in the pipe, in feet per second, and g = acceleration due to gravity, or 32.2.

The Babcock & Wilcox Company state in "Steam" that the resistance at the opening and that at a globe valve are each about the same as that caused by an additional length of straight pipe, as computed by the formula

$$\text{Additional length of pipe} = \frac{114 \times \text{diameter of pipe}}{1 + (3.6 \div \text{diameter})},$$

from which has been computed the following table:

Diameter in inches	2	2½	3	3½	4	5	6	7
Additional length, feet	7	10	13	16	20	28	36	44
Diameter in inches	8	10	12	15	18	20	22	24
Additional length, feet	53	70	88	115	143	162	181	200

The resistance to flow at a right-angled elbow is about equal to ⅔ that of a globe valve.

The above values are to be considered as being only approximations to the truth.

Example.—Find the discharge from a steam-pipe when the given length = 120 feet and the diameter = 8 inches, the pipe containing 6 right-angled elbows and two globe valves, the pressure at the two ends being respectively 105 and 103 pounds per square inch gauge.

The resistance to entrance, from the above table, for 8-inch pipe $=53$ feet; the resistance of 6 elbows $=6\times53\times\frac{2}{3}=212$ feet; the resistance of two globe valves $=2\times53=106$ feet; making a total resistance $=53+212+106=371$ feet of additional length of pipe. Therefore the steam would encounter the same resistance flowing through a straight 8-inch pipe whose length equals $120+371$, or 491 feet, as it would in flowing through the given pipe with its various resistances.

Then in the formula

$$W=c\sqrt{\frac{w(p-p_2)d^5}{L}},$$

$L=491$ feet; $p=105$ pounds per square inch; $p_2=103$ pounds per square inch; $d=8$ inches; c, for an 8-inch pipe, $=60.7$; and w, from table of Properties of Saturated Steam, $=0.27$.

Substituting in formula we get

$$W=60.7\sqrt{\frac{0.27(105-103)8^5}{491}}=364.$$

The pipe, then, under the stated conditions, would discharge approximately 364 pounds of steam per minute, or 21,800 pounds per hour; which, on the basis of 30 pounds per horse-power hour, would have a capacity of 728 boiler horse-powers. Since one pound of steam at 104 pounds gauge has a volume of 3.7 cubic feet, the pipe would discharge 1,350 cubic feet per minute, or 81,000 cubic feet per hour.

Non-conducting Coverings for Steam-pipes.—A bare pipe carrying steam, and made of iron, steel, or other conducting material, loses heat by convection to the surrounding air and by radiation to the surrounding objects, both of which cause a loss of steam by condensation.

This loss is lessened in practice by covering the outer surface of the steam-pipe with a material that will offer a greater resistance to the flow of heat than that offered by the material of the pipe.

A good material for this purpose should not suffer serious deterioration from the heat or vibration to which it would be subjected in practice; and in all cases where damage from fire might result, it should never consist of combustible matter. Under the conditions of practice, especially in places where it

may become damp, a good pipe covering should consist of materials that will not rapidly deteriorate, and should contain nothing that will seriously corrode the pipe.

Since air does not take up heat by radiation, but receives heat by contact with a hot body only, it would appear that the greater the porosity of a material—that is, the greater the percentage of volume of finely divided air it contains—the greater will be its non-conducting qualities. This is noticeably the case in the commercial pipe coverings that consist substantially of the same materials, when these materials contain different percentages of still air. In every case the more porous the material, other things being equal, the greater will be its non-conducting properties.

The following table contains averages made up from results obtained by a number of carefully conducted tests, and represent approximately what may be expected when these materials are properly applied as steam-pipe coverings in practice. The table gives the quantity of heat transmitted through covered steam-pipes, when that transmitted through a naked pipe is taken as 100, the covering, except where otherwise indicated, being one inch thick.

Kind of Covering.	Relative Amount of Heat Transmitted.
Naked pipe	100
Hair-felt, asbestos lined and canvas covered	16 to 18
Wool felt, " " " " "	20 " 22
Two layers of asbestos paper	70 " 80
Four " " " "	45 " 55
Asbestos mixed with some plaster of Paris	28 " 34
Magnesia mixed with a little asbestos fibre, canvas covered	18 " 20
Best mineral wool, lined and canvas covered	18 " 20
Pipe painted with black asphaltum	about 105
" " " white glossy paint	" 95

For coverings having values less than 25 in the above table, the values for thicknesses of covering of $1\frac{1}{2}$ and 2 inches (those in the table being for 1 inch, as noted) may be approximately obtained by multiplying respectively by 0.78 and 0.58. Thus a pipe covered with magnesia and canvas covered would transmit an amount, if $1\frac{1}{2}$ inches thick, $= (18 \text{ to } 20) \times 0.78 = 14 \text{ to } 15.5$; and if 2 inches thick an amount $= (18 \text{ to } 20) \times 0.58 = 10.5 \text{ to } 11.5$,

that transmitted by a similar bare pipe being 100 in the same length of time.

The following table gives the result of tests made by G. B. Dunford, of Hamilton, Ont., of various materials in regard to their quality as a non-conductor of heat.

Combination of asbestos, hair-felt, air space, and wood	100	per cent.
Asbestos and hair-felt chopped and mixed with lime putty	87	" "
A plastic cement manufactured by parties at Troy, N. Y., with ½ inch hair-felt outside	86.6	" "
Paper pulp mixed with lime putty, 1 inch, covered with sheeting of wood pulp	85	" "
Mineral wool cased with wood	81	" "
Mineral wool cased with sheet iron	79	" "
Charcoal	60	" "
Sawdust	41	" "
Loam and chopped straw sealed with wood	32	" "
Asbestos	29	" "
Coal ashes	24	" "
Air space	20	" "
Fire-brick	15	" "
Red brick	12	" "
Sand	9.3	" "

Steam.—Under the ordinary atmospheric pressure of 14.7 pounds per square inch, water boils at 212° F., passing off as steam, the temperature at which it boils varying with a variation in the pressure.

Dry Steam is steam not containing any free moisture. It may be either saturated or superheated.

Wet Steam is steam containing free moisture in the form of spray or mist, and has the same temperature as dry saturated steam of the same pressure.

Saturated Steam is steam in its normal state, that is, steam whose temperature is that due its pressure; by which is meant steam at the same temperature as that of the water from which it was generated and upon which it rests.

Superheated Steam is steam at a temperature above that due to its pressure.

A British Thermal Unit is the quantity of heat required

to raise one pound of water at 39°.1 F. through one degree of temperature.

THE TOTAL HEAT OF THE WATER is the number of British thermal units needed to raise one pound of water from 32° F. to the boiling-point under the given pressure.

THE LATENT HEAT OF STEAM is the number of British thermal units required to convert one pound of water, at the boiling-point, into steam of the same temperature.

THE TOTAL HEAT OF SATURATED STEAM is the number of heat-units required to raise a pound of water from 32° F. to the boiling-point, at the given pressure, plus the number required to evaporate the water at that temperature.

THE SPECIFIC HEAT OF STEAM is the quantity of heat required to raise the temperature of one pound of steam through one degree of temperature. In British units and near the saturation temperature it equals, at constant pressure, 0.48.

THE SPECIFIC GRAVITY OF STEAM at any temperature and pressure, as compared with air of same temperature and pressure, is approximately 0.622. One cubic inch of water evaporated into steam at 212° F. becomes 1646 cubic inches, that is, nearly 1 cubic foot.

Water in contact with saturated steam has the same temperature as the steam itself. Water introduced into superheated steam will be vaporized until the steam becomes saturated and its temperature becomes that due its pressure. Cold water, or water at a lower temperature than that of the steam, introduced into saturated steam will condense some of it, thus lowering both the temperature and pressure of the rest until the temperature again equals that due its pressure.

USEFUL RULES AND INFORMATION.—*Steam.*—A cubic inch of water evaporated under ordinary atmospheric pressure is converted into 1 cubic *foot* of steam (approximately).

The specific gravity of steam (at atmospheric pressure) is 0.411 that of air at 34° Fahr., and 0.0006 that of water at the same temperature.

26.32 cubic feet of steam at 212 degrees weigh 1 pound; 13.141 cubic feet of air weigh 1 pound at sea level.

Locomotives average a consumption of 3,000 gallons of water per 100 miles run.

The best-designed boilers, well set, with good draft and skilful firing, will evaporate from 7 to 10 pounds of water per pound of first-class coal.

In calculating horse-power of tubular or flue boilers, consider 15 square feet of heating surface equivalent to one *nominal* horse-power.

On 1 square foot of grate can be burned on an average from 10 to 12 pounds of hard coal, or 18 to 20 pounds of soft coal, per hour, with natural draft. With forced draft nearly double these amounts can be burned.

Steam-engines, in economy, vary from 14 to 60 pounds of feed-water and from 1½ to 7 pounds of coal per hour per indicated horse-power. See table below for duty of high-grade engines.

Condensing-engines require from 20 to 30 gallons of water, at an average low temperature, to condense the steam represented by every gallon of water evaporated in the boilers supplying engines—approximately for most engines, we say, from 1 to 1½ gallons condensing water per minute per indicated horse-power.

Surface condensers should have about 2 square feet of tube (cooling) surface per horse-power for a compound steam-engine. Ordinary engines will require more surface according to their economy in the use of steam. It is absolutely necessary to place air-pumps below condensers to get satisfactory results.

Ratio of Vacuum to Temperature (Fahrenheit) of Feed-water.

00	inches	vacuum	212°
11	"	"	190°
18	"	"	170°
22½	"	"	150°
25 *	"	"	135°
27½	"	"	112°
28½	"	"	92°
29	"	"	72°
29½	"	"	52°

Weight and Comparative Fuel Value of Wood.

1 cord air-dried hickory or hard maple weighs about 4500 pounds, and is equal to about 2000 pounds coal.

1 cord air-dried white oak weighs about 3850 pounds, and is equal to about 1715 pounds coal.

1 cord air-dried beech, red oak, or black oak weighs about 3250 pounds, and is equal to about 1450 pounds coal.

* Usually considered the standard point of efficiency—condenser and air-pump being well proportioned.

1 cord air-dried poplar (whitewood), chestnut, or elm weighs about 2350 pounds, and is equal to about 1050 pounds coal.

1 cord air-dried average pine weighs about 2000 pounds, and is equal to about 925 pounds coal.

From the above it is safe to assume that $2\frac{1}{4}$ pounds of dry wood is equal to 1 pound average quality of soft coal, and that the full value of the same *weight* of different woods is very nearly the same—that is, a pound of hickory is worth no more for fuel than a pound of pine, assuming both to be dry. It is important that the wood be dry, as each 10 per cent of water or moisture in wood will detract about 12 per cent from its value as fuel.

PIPE DATA.

Inside Diameter Nominal.	Internal Area in Inches.	Circumference of Pipe in Inches.	Length of Pipe in Feet per Sq. Ft. of Radiating Surface.	Number of Sq. Feet in 1 Lineal Foot of Pipe.	Contents in Gallons per Foot.	Weight in Pounds per Lineal Foot.	Number of Threads per Inch of Screw.
½	.3048	2.652	4.502	.221	.0102	½— 0.84	14
¾	.5333	3.299	3.637	.274	.0230	¾— 1.126	14
1	.8627	4.134	2.903	.344	.0408	1 — 1.670	11½
1¼	1.496	5.215	2.301	.434	.0638	1¼— 2.258	11½
1½	2.038	5.969	2.010	.497	.0918	1½— 2.694	11½
2	3.355	7.461	1.611	.621	.1632	2 — 3.667	11½
2½	4.783	9.032	1.328	.752	.2550	2½— 5.773	8
3	7.368	10.99	1.091	.916	.3673	3 — 7.547	8
3½	9.837	12.56	.955	1.044	.4998	3½— 9.055	8
4	12.730	14.13	.849	1.178	.6528	4 —10.728	8
4½	15.939	15.70	.765	1.309	.8263	4½—12.492	8
5	19.990	17.47	.629	1.656	1.0200	5 —14.564	8
6	28.889	20.81	.577	1.733	1.5500	6 —18.767	8

Duty of Steam-engines.—A well-known engineer of high authority gives the following comparative figures, showing the economy of high-grade steam-engines in actual practice:

Type of Engine.	Temperature of Feed-water.	Pounds of Water Evaporated per Pound of Cumberland Coal.	Pounds of Steam per I.H.P. Used per Hour.	Pounds of Cumberland Coal Used per I.H.P. per Hour.	Cost per I.H.P. per Hour, Supposing Coal at $6 per Ton.
Non-condensing.	210°	10.5	29.	2.75	$0.0073
Condensing.	100°	9.4	20.	2.12	0.0056
Compound jacketed.	100°	9.4	17	1.81	0.0045
Triple-expansion jacketed.	100°	9.4	13.6	1.44	0.0036

The effect of a good condenser and air-pump should be to make available about 10 pounds more mean effective pressure with the same terminal pressure; or to give the same mean effective pressure with a correspondingly less terminal pressure. When the load on the engine requires 20 pounds M.E.P., the condenser does half the work; at 30 pounds, one-third of the work; at 40 pounds, one-fourth, and so on. It is safe to assume that practically the condenser will save from one-fourth to one-third of the fuel, and it can be applied to any engine, cut-off, or throttling where a sufficient supply of water is available.

Sizes of Mains for Indirect Heating.—Where there are only one or two indirect stacks on a job, run a separate main from the boiler to the indirect radiator.

On account of the slight elevation of the indirect stacks over the heater, the mains for hot water should be of ample size because of the slow velocity of the flow. The table below will be found to give good results.

For Steam		For Water	
Size Pipe	Ft. Radiation	Size Pipe	Ft. Radiation
1¼ in.	60 sq. ft.	1¼ in.	60 sq. ft.
1½ "	120 "	1½ "	100 "
2 "	250 "	2 "	225 "
2½ "	400 "	2½ "	325 "
3 "	750 "	3 "	500 "
3½ "	1000 "	3½ "	650 "
4 "	1500 "	4 "	850 "
5 "	2500 "	5 "	1500 "
6 "	3600 "	6 "	2500 "

Comparison of Thermometric Scales.—To convert the degrees of Centigrade into those of Fahrenheit, multiply by 9 divide by 5, and add 32.

To convert degrees of Centigrade into those of Réaumur, multiply by 4 and divide by 5.

To convert degrees of Fahrenheit into those of Centigrade, deduct 32, multiply by 5, and divide by 9.

To convert degrees of Fahrenheit into those of Réaumur, deduct 32, divide by 9, and multiply by 4.

To convert degrees of Réaumur into those of Centigrade, multiply by 5 and divide by 4.

To convert degrees of Réaumur into those of Fahrenheit, multiply by 9, divide by 4, and add 32.

In De Lisle's thermometer, used in Russia, the graduation begins at boiling-point, which is marked zero, and the freezing-point is 150.

SIZES OF STEAM MAINS.

Radiation.	One-pipe Work.	Two-pipe Work.
40 to 50 square feet	1 inch	$\frac{3}{4}\times\frac{3}{4}$ inch
100 to 125 "	$1\frac{1}{4}$ "	$1\times\frac{3}{4}$ "
125 to 250 "	$1\frac{1}{2}$ "	$1\frac{1}{4}\times1$ "
250 to 400 "	2 "	$1\frac{1}{2}\times1\frac{1}{4}$ "
400 to 650 "	$2\frac{1}{2}$ "	$2\times1\frac{1}{2}$ "
650 to 900 "	3 "	$2\frac{1}{2}\times2$ "
900 to 1250 "	$3\frac{1}{2}$ "	$3\times2\frac{1}{2}$ "
1250 to 1600 "	4 "	$3\frac{1}{2}\times3$ "
1600 to 2050 "	$4\frac{1}{2}$ "	$4\times3\frac{1}{2}$ "
2050 to 2500 "	5 "	$4\frac{1}{2}\times4$ "
2500 to 3600 "	6 "	$5\times4\frac{1}{2}$ "
3600 to 5000 "	7 "	6×5 "
5000 to 6500 "	8 "	7×6 "
6500 to 8100 "	9 "	8×6 "
8100 to 10000 "	10 "	9×6 "

SIZES OF HOT WATER MAINS.

Direct Radiation.	Pipe.	Direct Radiation.	Pipe.
75 to 125 square feet	$1\frac{1}{4}$ inch	950 to 1200 square inch	4 inch
125 to 200 "	$1\frac{1}{2}$ "	1200 to 1500 "	$4\frac{1}{2}$ "
200 to 300 '	2 "	1500 to 1900 "	5 "
300 to 400 "	$2\frac{1}{2}$ "	1900 to 2300 "	$5\frac{1}{2}$ "
400 to 700 "	3 "	2300 to 2800 "	6 "
700 to 950 "	$3\frac{1}{2}$ "		

TABLE SHOWING EXPANSION OF WROUGHT IRON PIPE.

Initial Temperature.	Increase in length per 100 feet when heated to									
	160°	180°	200°	212°	228°	240°	250°	259°	267°	274°
Zero, in.	1.28	1.44	1.60	1.69	1.82	1.92	2.00	2.07	2.13	2.20
32° in.	1.02	1.18	1.34	1.43	1.56	1.66	1.74	1.81	1.87	1.94
64° in.	.77	.93	1.09	1.18	1.31	1.41	1.49	1.56	1.61	1.69
	Hot Water			Wat'r Boils	5 lbs.	10 lbs.	15 lbs.	20 lbs.	25 lbs.	30 lbs.

Wrought iron pipe expands, in inches, per 100 feet, 4–5 of the increase in temperature of steam or water it is subjected to, over the temperature at the time of installation, divided by 100.

Example. — Temperature when installed, 32 degreees, 10 pounds pressure = 240 degrees, difference 208 degrees, 4–5 of which equals 1 66–100 inches expansion per 100 feet.

Combustion. — Ordinary, 3 to 5 pounds of coal per square foot of grate per hour.

Fast, 10 pounds of coal per square foot of grate per hour.

Evaporation. — 1 cubic inch of water evaporated under atmospheric pressure is converted into 1642 cubic inches of steam.

Heat Unit is the measure of energy required to change the temperature of 1 pound of water at 62° F. one degree. It is equivalent to 778 foot-pounds.

Coal in Bins. — Anthracite coal requires 36 cubic feet of space per ton of 2,000 pounds.

Stove bituminous coal requires 40 cubic feet of sqace per ton of 2,000 pounds.

JOULE'S MECHANICAL EQUIVALENT OF HEAT. — Experimental determinations rate one unit of heat equal to 772 foot-pounds.

LATENT HEAT OF LIQUEFACTION is defined as the number of units of heat absorbed by 1 lb. of a solid, in passing to the liquid state.

LATENT HEAT OF VAPORIZATION is the number of units absorbed by 1 pound of a liquid in the act of passing into vapor. A pound of water at 212 degrees passing into steam at 212 degrees absorbs as much heat as would have raised the temperature of the water 966 degrees, if it had not become latent.

HEAT REQUIRED TO CONVERT WATER TO STEAM OF DIFFERENT PRESSURES

(Treatise on Heat, by Thomas Box.)

Pressure Above the Atmosphere in Lbs per Square Inch.	Temperature of the Steam.	Units per Lb. of Water.	
		Latent Heat.	Total heat from 32°
7	232°	950	1152
15	250°	937	1157
20	259°	931	1160
25	267°	926	1163
30	274°	920	1165
45	292°	908	1171
60	307°	897	1175
75	320°	888	1179
100	338°	876	1184
125	353°	865	1189
150	366°	856	1193
175	377°	848	1196
200	388°	840	1200

One Foot-pound, equals one pound raised one foot high,
One Horse Power, equals 550 foot-pounds per second,
or 33,000 foot-pounds per minute,
or 1,980,000 foot-pounds per hour.

The Indicated H. P. of a Steam Engine is measured by the number of foot-pounds exerted on the piston, which for a double acting engine equals the average steam pressure on the piston, multiplied by the piston speed in feet per minute, divided by 33,000.

STEAM TABLE.

Temperature and Weight of Steam at different pressures from 1 pound per square inch to 300 pounds, and the Quantity of Steam produced from 1 cubic foot of water, according to pressure.

Total Pressure per Square Inch measured from a Vacuum.	Pressure above Atmosphere.	Sensible Temperature in Fahrenheit Degrees.	Total Heat in Degrees from Zero of Fahrenheit.	Weight of One Cubic Foot of Steam.	Relative Volume of Steam Compared with Water from which it was raised.	Total Pressure per Square Inch measured from a Vacuum.
1	...	102.1	1144.5	.0030	20582	1
2	...	126.3	1151.7	.0058	10721	2
3	...	141.6	1156.6	.0085	7322	3
4	...	153.1	1160.1	.0112	5583	4
5	...	162.3	1162.9	.0138	4527	5
6	...	170.2	1165.3	.0163	3813	6
7	...	176.9	1167.3	.0189	3298	7
8	...	182.9	1169.2	.0214	2909	8
9	...	188.3	1170.8	.0239	2604	9
10	...	193.3	1172.3	.0264	2358	10
11	...	197.8	1173.7	.0289	2157	11
12	...	202.0	1175.0	.0314	1986	12
13	...	205.9	1176.2	.0338	1842	13
14	...	209.6	1177.3	.0362	1720	14
14.7	.0	212.0	1178.1	.0380	1642	14.7
15	.3	213.1	1178.4	.0387	1610	15
16	1.3	216.3	1179.4	.0411	1515	16
17	2.3	219.6	1180.3	.0435	1431	17
18	3.3	222.4	1181.2	.0459	1357	18
19	4.3	225.3	1182.1	.0483	1290	19
20	5.3	228.0	1182.9	.0507	1229	20
21	6.3	230.6	1183.7	.0531	1174	21
22	7.3	233.1	1184.5	.0555	1123	22
23	8.3	235.5	1185.2	.0580	1075	23
24	9.3	237.8	1185.9	.0601	1036	24
25	10.3	240.1	1186.6	.0625	996	25
26	11.3	242.3	1187.3	.0650	958	26
27	12.3	244.4	1187.8	.0673	926	27
28	13.3	246.4	1188.4	.0696	895	28
29	14.3	248.4	1189.1	.0719	866	29

STEAM TABLE.—*Continued.*

Total Pressure per Square Inch measured from a Vacuum.	Pressure above Atmosphere.	Sensible Temperature in Fahrenheit Degrees.	Total Heat in Degrees from Zero of Fahrenheit.	Weight of One Cubic Foot of Steam.	Relative Volume of Steam Compared with Water from which it was Raised.	Total Pressure per Square Inch measured from a Vacuum.
30	15.3	250.4	1189.8	.0743	838	30
31	16.3	252.2	1190.4	.0766	813	31
32	17.3	254.1	1190.9	.0789	789	32
33	18.3	255.9	1191.5	.0812	767	33
34	19.3	257.6	1192.0	.0835	746	34
35	20.3	259.3	1192.5	.0858	726	35
36	21.3	260.9	1193.0	.0881	707	36
37	22.3	262.6	1193.5	.0905	688	37
38	23.3	264.2	1194.0	.0929	671	38
39	24.3	265.8	1194.5	.0952	655	39
40	25.3	267.3	1194.9	.0974	640	40
41	26.3	268.7	1195.4	.0996	625	41
42	27.3	270.2	1195.8	.1020	611	42
43	28.3	271.6	1196.2	.1042	598	43
44	29.3	273.0	1196.6	.1065	595	44
45	30.3	274.4	1197.1	.1089	572	45
46	31.3	275.8	1197.5	.1111	561	46
47	32.3	277.1	1197.9	.1133	550	47
48	33.3	278.4	1198.3	.1156	539	48
49	34.3	279.7	1198.7	.1179	529	49
50	35.3	281.0	1199.1	.1202	518	50
51	36.3	282.3	1199.5	.1224	509	51
52	37.3	283.5	1199.9	.1246	500	52
53	38.3	284.7	1200.3	.1269	491	53
54	39.3	285.9	1200.6	.1291	482	54
55	40.3	287.1	1201.0	.1314	474	55
56	41.3	288.2	1201.3	.1336	466	56
57	42.3	289.3	1201.7	.1364	458	57
58	43.3	290.4	1202.0	.1380	451	58
59	44.3	291.6	1202.4	.1403	444	59
60	45.3	292.7	1202.7	.1425	437	60
61	46.3	293.8	1203.1	.1447	430	61
62	47.3	294.8	1203.4	.1469	424	62
63	48.3	295.9	1203.7	.1493	417	63
64	49.3	296.9	1204.0	.1516	411	64
65	50.3	298.0	1204.3	.1538	405	65
66	51.3	299.0	1204.6	.1560	399	66
67	52.3	300.0	1204.9	.1583	393	67
68	53.3	300.9	1205.2	.1605	388	68

STEAM TABLE.—*Continued.*

Total Pressure per Square Inch measured from a Vacuum.	Pressure above Atmosphere.	Sensible Temperature in Fahrenheit Degrees.	Total Heat in Degrees from Zero of Fahrenheit.	Weight of One Cubic Foot of Steam.	Relative Volume of Steam Compared with Water from which it was Raised.	Total Pressure per Square Inch measured from a Vacuum.
69	54.3	301.9	1205.5	.1627	383	69
70	55.3	302.9	1205.8	.1648	378	70
71	56.3	303.9	1206.1	.1670	373	71
72	57.3	304.8	1206.3	.1692	368	72
73	58.3	305.7	1206.6	.1714	363	73
74	59.3	306.6	1206.9	.1736	359	74
75	60.3	307.5	1207.2	.1759	353	75
76	61.3	308.4	1207.4	.1782	349	76
77	62.3	309.3	1207.7	.1804	345	77
78	63.3	310.2	1208.0	.1826	341	78
79	64.3	311.1	1208.3	.1848	337	79
80	65.3	312.0	1208.5	.1869	333	80
81	66.3	312.8	1208.8	.1891	329	81
82	67.3	313.6	1209.1	.1913	325	82
83	68.3	314.5	1209.4	.1935	321	83
84	69.3	315.3	1209.6	.1957	318	84
85	70.3	316.1	1209.9	.1980	314	85
86	71.3	316.9	1210.1	.2002	311	86
87	72.3	317.8	1210.4	.2024	308	87
88	73.3	318.6	1210.6	.2044	305	88
89	74.3	319.4	1210.9	.2067	301	89
90	75.3	320.2	1211.1	.2089	298	90
91	76.3	321.0	1211.3	.2111	295	91
92	77.3	321.7	1211.5	.2133	292	92
93	78.3	322.5	1211.8	.2155	289	93
94	79.3	323.3	1212.0	.2176	286	94
95	80.3	324.1	1212.3	.2198	283	95
96	81.3	324.8	1212.5	.2219	281	96
97	82.3	325.6	1212.8	.2241	278	97
98	83.3	326.3	1213.0	.2263	275	98
99	84.3	327.1	1213.2	.2285	272	99
100	85.3	327.9	1213.4	.2307	270	100
101	86.3	328.5	1213.6	.2329	267	101
102	87.3	329.1	1213.8	.2351	265	102
103	88.3	329.9	1214.0	.2373	262	103
104	89.3	330.6	1214.2	.2393	260	104
105	90.3	331.3	1214.4	.2414	257	105
106	91.3	331.9	1214.6	.2435	255	106
107	92.3	332.6	1214.8	.2456	253	107

STEAM TABLE. — *Continued.*

Total Pressure per Square Inch measured from a Vacuum.	Pressure above Atmosphere.	Sensible Temperature in Fahrenheit Degrees.	Total Heat in Degrees from Zero of Fahrenheit.	Weight of One Cubic Foot of Steam.	Relative Volume of Steam Compared with Water from which it was raised.	Total Pressure per Square Inch measured from a Vacuum.
108	93.3	333.3	1215.0	.2477	251	108
109	94.3	334.0	1215.3	.2499	249	109
110	95.3	334.6	1215.5	.2521	247	110
111	96.3	335.3	1215.7	.2543	245	111
112	97.3	336.0	1215.9	.2564	243	112
113	98.3	336.7	1216.1	.2586	241	113
114	99.3	337.4	1216.3	.2607	239	114
115	100.3	338.0	1216.5	.2628	237	115
116	101.3	338.6	1216.7	.2649	235	116
117	102.3	339.3	1216.9	.2674	233	117
118	103.3	339.9	1217.1	.2696	231	118
119	104.3	340.5	1217.3	.2738	229	119
120	105.3	341.1	1217.4	.2759	227	120
121	106.3	341.8	1217.6	.2780	225	121
122	107.3	342.4	1217.8	.2801	224	122
123	108.3	343.0	1218.0	.2822	222	123
124	109.3	343.6	1218.2	.2845	221	124
125	110.3	344.2	1218.4	.2867	219	125
126	111.3	344.8	1218.6	.2889	217	126
127	112.3	345.4	1218.8	.2911	215	127
128	113.3	346.0	1218.9	.2933	214	128
129	114.3	346.6	1219.1	.2955	212	129
130	115.3	347.2	1219.3	.2977	211	130
131	116.3	347.8	1219.5	.2999	209	131
132	117.3	348.3	1219.6	.3020	208	132
133	118.3	348.9	1219.8	.3040	206	133
134	119.3	349.5	1220.0	.3060	205	134
135	120.3	350.1	1220.2	.3080	203	135
136	121.3	350.6	1220.3	.3101	202	136
137	122.3	351.2	1220.5	.3121	200	137
138	123.3	351.8	1220.7	.3142	199	138
139	124.3	352.4	1220.9	.3162	198	139
140	125.3	352.9	1221.0	.3184	197	140
141	126.3	353.5	1221.2	.3206	195	141
142	127.3	354.0	1221.4	.3228	194	142
143	128.3	354.5	1221.6	.3258	193	143
144	129.3	355.0	1221.7	.3273	192	144
145	130.3	355.6	1221.9	.3294	190	145
146	131.3	356.1	1222.0	.3315	189	146

STEAM TABLE.—*Continued.*

Total Pressure per Square Inch measured from a Vacuum.	Pressure above Atmosphere.	Sensible Temperature in Fahrenheit Degrees.	Total Heat in Degrees from Zero of Fahrenheit.	Weight of One Cubic Foot of Steam.	Relative Volume of Steam Compared with Water from which it was Raised.	Total Pressure per Square Inch measured from a Vacuum.
147	132.3	356.7	1222.2	.3336	188	147
148	133.3	357.2	1222.3	.3357	187	148
149	134.3	357.8	1222.5	.3377	186	149
150	135.3	358.3	1222.7	.3397	184	150
155	140.3	361.0	1223.5	.3500	179	155
160	145.3	363.4	1224.2	.3607	174	160
165	150.3	366.0	1224.9	.3714	169	165
170	155.3	368.2	1225.7	.3821	164	170
175	160.3	370.8	1226.4	.3928	159	175
180	165.3	372.9	1227.1	.4035	155	180
185	170.3	375.3	1227.8	.4142	151	185
190	175.3	377.5	1228.5	.4250	148	190
195	180.3	379.7	1229.2	.4357	144	195
200	185.3	381.7	1229.8	.4464	141	200
210	195.3	386.0	1231.1	.4668	135	210
220	205.3	389.9	1232.8	.4872	129	220
230	215.3	393.8	1233.5	.5072	123	230
240	225.3	397.5	1234.6	.5270	119	240
250	235.3	401.1	1235.7	.5471	114	250
260	245.3	404.5	1236.8	.5670	110	260
270	255.3	407.9	1237.8	.5871	106	270
280	265.3	411.2	1238.8	.6070	102	280
290	275.3	414.4	1239.8	.6268	99	290
300	285.3	417.5	1240.7	.6469	96	300

HOW TO DISTINGUISH STEEL FROM IRON PIPE.

Iron pipe is rough in appearance and the scale on it is heavy, whereas the scale on steel pipe is very light and has the appearance of small blisters or bubbles, underneath which the surface is smooth and somewhat white. Steel pipe seldom breaks when flattened, but if a fracture does occur it will be noticed that the grain is very fine. Iron pipe when subjected to this test breaks easily, and shows a coarse fracture, due to the long fiber of the material.

Dull dies will not work successfully on steel pipe, as they will tear, owing to the softness of the metal.

HEAT UNITS AND WEIGHT OF WATER.

Heat units in water, between 32 and 212 degrees Fahrenheit and weight of water per cubic foot.

Tem. Deg. Fahr.	Heat Units.	Weight, lbs. per cub. ft.	Tem. Deg. Fahr.	Heat Units.	Weight, lbs. per cub. ft.	Tem. Deg. Fahr.	Heat Units.	Weight, lbs. per cub. ft.
32	0.	62.42	123	91.16	61.68	168	136.44	60.81
35	3.	62.42	124	92.17	61.67	169	137.45	60.79
40	8.	62.42	125	93.17	61.65	170	138.45	60.77
45	13.	62.42	126	94.17	61.63	171	139.46	60.75
50	18.	62.41	127	95.18	61.61	172	140.47	60.73
52	20.	62.40	128	96.18	61.60	173	141.48	60.70
54	22.01	62.40	129	97.19	61.58	174	142.49	60.68
56	24.01	62.39	130	98.19	61.56	175	143.50	60.66
58	26.01	62.38	131	99.20	61.54	176	144.51	60.64
60	28.01	62.37	132	100.20	61.52	177	145.52	60.62
62	30.01	62.36	133	101.21	61.51	178	146.52	60.59
64	32.01	62.35	134	102.21	61.49	179	147.53	60.57
66	34.02	62.34	135	103.22	61.47	180	148.54	60.55
68	36.02	62.33	136	104.22	61.45	181	149.55	60.53
70	38.02	62.31	137	105.23	61.43	182	150.56	60.50
72	40.02	62.30	138	106.23	61.41	183	151.57	60.48
74	42.03	62.28	139	107.24	61.39	184	152.58	60.46
76	44.03	62.27	140	108.25	61.37	185	153.59	60.44
78	46.03	62.25	141	109.25	61.36	186	154.60	60.41
80	48.04	62.23	142	110.26	61.34	187	155.61	60.39
82	50.04	62.21	143	111.26	61.32	188	156.62	60.37
84	52.04	62.19	144	112.27	61.30	189	157.63	60.34
86	54.05	62.17	145	113.28	61.28	190	158.64	60.32
88	56.05	62.15	146	114.28	61.26	191	159.65	60.29
90	58.06	62.13	147	115.29	61.24	192	160.67	60.27
92	60.06	62.11	148	116.29	61.22	193	161.68	60.25
94	62.06	62.09	149	117.30	61.20	194	162.69	60.22
96	64.07	62.07	150	118.31	61.18	195	163.70	60.20
98	66.07	62.05	151	119.31	61.16	196	164.71	60.17
100	68.08	62.02	152	120.32	61.14	197	165.72	60.15
102	70.09	62.00	153	121.33	61.12	198	166.73	60.12
104	72.09	61.97	154	122.33	61.10	199	167.74	60.10
106	74.10	61.95	155	123.34	61.08	200	168.75	60.07
108	76.10	61.92	156	124.35	61.06	201	169.77	60.05
110	78.11	61.89	157	125.35	61.04	202	170.78	60.02
112	80.12	61.86	158	126.36	61.02	203	171.79	60.00
114	82.13	61.83	159	127.37	61.00	204	172.80	59.97
115	83.13	61.82	160	128.37	60.98	205	173.81	59.95
116	84.13	61.80	161	129.38	60.96	206	174.83	59.92
117	85.14	61.78	162	130.39	60.94	207	175.84	59.89
118	86.14	61.77	163	131.40	60.92	208	176.85	59.87
119	87.15	61.75	164	132.41	60.90	209	177.86	59.84
120	88.15	61.74	165	133.41	60.87	210	178.87	59.82
121	89.15	61.72	166	134.42	60.85	211	179.89	59.79
122	90.16	61.70	167	135.43	60.83	212	180.90	59.76

HEATING APPARATUS, DRYING-ROOMS, GAS- AND WATER-PIPES.

The following rules regarding the installation of heating apparatus are taken from the New York Building Code, 1899:

Sec. 84. *Heating-furnace Sand Boilers.*—A brick-set boiler shall not be placed on any wood or combustible floor or beams. Wood or combustible floors and beams under and not less than three feet in front and one foot on the sides of all portable boilers

shall be protected by a suitable brick foundation of not less than two courses of brick well laid in mortar on sheet iron; the said sheet iron shall extend at least twenty-four inches outside of the foundation at the sides and front. Bearing lines of bricks, laid on the flat, with air-spaces between them, shall be placed on the foundation to support a cast-iron ash-pan of suitable thickness, on which the base of the boiler shall be placed, and shall have a flange, turned up in the front and on the sides, four inches high; said pan shall be in width not less than the base of the boiler and shall extend at least two feet in front of it. If a boiler is supported on a cast-iron base with a bottom of the required thickness for an ash-pan, and is placed on bearing lines of brick in the same manner as specified for an ash-pan, then an ash-pan shall be placed in front of the said base and shall not be required to extend under it. All lath-and-plaster and wood ceilings and beams over and to a distance of not less than four feet in front of all boilers shall be shielded with metal. The distance from the top of the boiler to said shield shall be not less than twelve inches. No combustible partition shall be within four feet of the sides and back and six feet from the front of any boiler, unless said partition shall be covered with metal to the height of at least three feet above the floor, and shall extend from the end or back of the boiler to at least five feet in front of it; then the distance shall be not less than two feet from the sides and five feet from the front of the boiler. All brick hot-air furnaces shall have two covers, with an air-space of at least four inches between them; the inner cover of the hot-air chamber shall be either a brick arch or two courses of brick laid on galvanized iron or tin, supported on iron bars; the outside cover, which is the top of the furnace, shall be made of brick or metal supported on iron bars, and so constructed as to be perfectly tight, and shall be not less than four inches below any combustible ceiling or floor-beams. The walls of the furnace shall be built hollow in the following manner: One inner and one outer wall, each four inches in thickness, properly bonded together with an air-space of not less than three inches between them. Furnaces must be built at least four inches from all woodwork. The cold-air boxes of all hot-air furnaces shall be made of metal, brick, or other incombustible material, for a distance of at least ten feet from the furnace. All portable hot-air furnaces shall be placed at least two feet from any wood or combustible partition or ceiling,

unless the partitions and ceilings are properly protected by a metal shield, when the distance shall be not less than one foot. Wood floors under all portable furnaces shall be protected by two courses of brickwork well laid in mortar on sheet iron. Said brickwork shall extend at least two feet beyond the furnace in front of the ash-pan.

Sec. 85. *Registers.*—Registers located over a brick furnace shall be supported by a brick shaft built up from the cover of the hot-air chamber; said shaft shall be lined with a metal pipe, and all wood beams shall be trimmed away not less than four inches from it. Where a register is placed on any woodwork in connection with a metal pipe or duct the end of the said pipe or duct shall be flanged over on the woodwork under it. All registers for hot-air furnaces placed in any woodwork or combustible floors shall have stone or iron borders firmly set in plaster of Paris or gauged mortar. All register-boxes shall be made of tin plate or galvanized iron with a flange on the top to fit the groove in the frame, the register to rest upon the same; there shall be an open space of two inches on all sides of the register-box, extending from the under side of the border to and through the ceiling below. The said opening shall be fitted with a tight tin or galvanized-iron casing, the upper end of which shall be turned under the frame. When a register-box is placed in the floor over a portable furnace, the open space on all sides of the register-box shall be not less than three inches. When only one register is connected with a furnace said register shall have no valve.

Sec. 86. *Drying-rooms.*—All walls, ceilings, and partitions inclosing drying-rooms, when not made of fire-proof material, shall be wire-lathed and plastered, or covered with metal, tile, or other hard incombustible material.

Sec. 87. *Ranges and Stoves.*—Where a kitchen range is placed from twelve to six inches from a wood stud-partition, the said partition shall be shielded with metal from the floor to the height of not less than three feet higher than the range; if the range is within six inches of the partition, then the studs shall be cut away and framed three feet higher and one foot wider than the range, and filled in to the face of the said stud-partition with brick or fire-proof blocks, and plastered thereon. All ranges on wood or combustible floors and beams that are not supported on legs and have ash-pans three inches or more above their base, shall be set on suitable brick foundations,

consisting of not less than two courses of brick well laid in mortar on sheet iron, except small ranges, such as are used in apartment houses, that have ash-pans three inches or more above their base, which shall be placed on at least one course of brick-work on sheet iron or cement. No range shall be placed against a furred wall. All lath-and-plaster or wood ceilings over all large ranges, and ranges in hotels and restaurants, shall be guarded by metal hoods placed at least nine inches below the ceiling. A ventilating-pipe connected with a hood over a range shall be at least nine inches from all lath-and-plaster or wood-work, and shielded. If the pipe is less than nine inches from lath-and-plaster and woodwork, then the pipe shall be covered with one inch of asbestos plaster on wire mesh. No ventilating-pipe connected with a hood over a range shall pass through any floor. Laundry-stoves on wood or combustible floors shall have a course of bricks, laid on metal, on the floor under and extended twenty-four inches on all sides of them. All stoves for heating purposes shall be properly supported on iron legs resting on the floor three feet from all lath-and-plaster or wood work; if the lath-and-plaster or woodwork is properly protected by a metal shield, then the distance shall be not less than eighteen inches. A metal shield shall be placed under and twelve inches in front of the ash-pan of all stoves that are placed on wood floors. All low gas-stoves shall be placed on iron stands, or the burners shall be at least six inches above the base of the stoves, and metal guard-plates placed four inches below the burners, and all wood work under them shall be covered with metal.

Pure Air. — Pure air is a mixture of oxygen and nitrogen in the following proportions: by volume 20.91 parts oxygen to 79.09 parts nitrogen; by weight 23.15 parts oxygen to 76.85 parts nitrogen. Air in nature always contains other constituents such as dust, carbon dioxide, ammonia, ozone and water vapor.

Pure Water. — Pure water is a chemical compound of one volume of oxygen (O) and two of hydrogen (H), and its chemical symbol is H_2O.

DATA FOR INDIRECT STEAM AND HOT WATER RADIATORS.

FLUE SIZES FOR INDIRECT STEAM RADIATORS.

Feet of Heating Surface, Square Feet.	Area Cold Air Supply, Square Inches.	Area Hot Air Flue, Square Inches.	Size of Register, Inches.
15	36	48	8×12
25	54	72	9×12
30	72	96	10×14
45	90	120	12×15
65	108	144	12×19
78	126	168	14×22
91	144	192	14×24
104	162	216	16×20
117	180	240	16×24
130	198	264	20×20
143	216	288	20×24
156	234	312	20×24

FOR INDIRECT HOT WATER.

Feet of Heating Surface, Square Feet Water.	Area Cold Air Supply, Square Inches.	Area Hot Air Flue, Square Inches.	Size of Register Inches.
25	36	48	8×12
50	54	72	9×12
75	72	96	10×14
100	90	120	12×15
125	108	144	12×19
150	126	168	14×22
175	144	192	14×24
200	162	216	16×20
225	180	240	16×24
260	198	264	20×20
275	216	288	20×24
300	234	312	20×24

The above table applies to floor registers.
For side wall add 25 per cent.

Hanging Indirect Stacks. — For cleanliness, as well as for obtaining the best results, indirect stacks should be hung one side of the register or warm air flue opening, receiving the warm air duct from the end of the indirect casing close to the top and the cold air duct at the bottom of the opposite end. A space of 10 inches (preferably 12) should be allowed for warm air above the stack. The top of the casing should pitch upward toward

its exit at least 1 inch or more in its length. A space of at least 6 inches (preferably 8) should be allowed for cold air below the stack and between it and the casing.

STANDARD SIZES OF HORIZONTAL TUBULAR BOILERS.

E. Hodge & Co., East Boston.

Diam. of Boiler.	Length of Shell.	Number of Tubes.	Size of Tubes.	Thickness of Shell.	Thickness of Heads.	Sq. Feet Heating.	Nominal Horse Power.	Approx. Weight Boiler.	Approx. Weight Castings.	Approx. Total Weight.
			In.	In.	In.					
24	5–8	26	2	$\frac{1}{4}$	$\frac{3}{8}$	80	5	1040	920	1960
24	6–8	26	2	$\frac{1}{4}$	$\frac{3}{8}$	95	6	1165	920	2085
24	7–8	26	2	$\frac{1}{4}$	$\frac{3}{8}$	110	7	1290	920	2210
30	6–9	36	2	$\frac{1}{4}$	$\frac{3}{8}$	129	9	1550	1400	2950
36	7–9	36	2	$\frac{1}{4}$	$\frac{3}{8}$	150	10	1750	1475	3225
30	8–9	36	2	$\frac{1}{4}$	$\frac{3}{8}$	170	11	1950	1475	3425
36	8–3	34	$2\frac{1}{2}$	$\frac{1}{4}$	$\frac{3}{8}$	183	12	2160	2025	4185
36	9–3	34	$2\frac{1}{2}$	$\frac{1}{4}$	$\frac{3}{8}$	208	14	2400	2025	4425
36	10–3	34	$2\frac{1}{2}$	$\frac{1}{4}$	$\frac{3}{8}$	233	16	2550	2100	4650
36	11–3	28	3	$\frac{1}{4}$	$\frac{3}{8}$	222	15	2750	2250	5000
36	12–3	28	3	$\frac{1}{4}$	$\frac{3}{8}$	243	16	2900	2250	5150
36	13–3	28	3	$\frac{1}{4}$	$\frac{3}{8}$	264	18	3200	2450	5650
42	10–3	38	3	$\frac{5}{16}$	$\frac{3}{8}$	309	21	3600	2500	6100
42	11–3	38	3	$\frac{5}{16}$	$\frac{3}{8}$	341	23	4050	2500	6550
42	12–3	38	3	$\frac{5}{16}$	$\frac{3}{8}$	374	25	4260	2725	6985
42	13–3	38	3	$\frac{5}{16}$	$\frac{3}{8}$	407	27	4525	2725	7250
42	14–3	38	3	$\frac{5}{16}$	$\frac{3}{8}$	440	29	4850	2725	7575
48	11–3	49	3	$\frac{5}{16}$	$\frac{3}{8}$	432	29	5150	3250	8400
48	12–3	49	3	$\frac{5}{16}$	$\frac{3}{8}$	474	32	5550	3360	8910
48	13–3	49	3	$\frac{5}{16}$	$\frac{3}{8}$	515	24	6000	3360	9360
48	14–3	49	3	$\frac{5}{16}$	$\frac{3}{8}$	557	37	6300	3360	9660
48	15–3	41	$3\frac{1}{2}$	$\frac{5}{16}$	$\frac{3}{8}$	593	40	6750	3750	10500
48	16–3	41	$3\frac{1}{2}$	$\frac{5}{16}$	$\frac{3}{8}$	633	42	7150	3900	11050
54	15–3	49	$3\frac{1}{2}$	$\frac{11}{32}$	$\frac{3}{8}$	703	47	7800	4200	12000
54	16–3	49	$3\frac{1}{2}$	$\frac{11}{32}$	$\frac{3}{8}$	752	50	8200	4400	12600

BOILING POINTS OF VARIOUS FLUIDS.

Charles H. Haswell.

Water in Vacuum	98°	Refined Petroleum	316°
Water, Atmospheric Pressure	212°	Turpentine	315°
Alcohol	173°	Sulphur	570°
Sulphuric Acid	240°	Linseed Oil	597°

Boiler and Pipe Covering. — The value of good boiler and pipe covering has not been generally recognized as it should have been. It is claimed by some experimenters that a lineal foot of two inch pipe in use the year round will condense more

steam than a dollar's worth of coal will make, and since few systems have less than 20 or 25 per cent of their total tax on the heater in the form of mains, the saving of coal, or, what amounts to the same, the added efficiency of the heater becomes manifest.

For covering boilers and pipes, asbestos is generally used and is a high grade non-conductor easily applied. For pipe covering it comes molded in sections but for boilers it is usually applied in a plastic state and allowed to harden. As a reinforcement woven wire of a large mesh is often bedded in the layer of asbestos.

Plastic asbestos is very easily applied if the following directions are followed.

Do not try to make it adhere to a cold boiler; have the surface warm.

Mix the asbestos for the first coat rather stiff and apply, making no endeavor to get a smooth surface. A good way is to throw it on by the handful like throwing a snowball.

Let the first coat set hard, and then apply the second coat with a trowel, trowelling it to a smooth surface.

A fine surfacing finish can be made by mixing a little Portland cement with the asbestos for the finishing coat. This will set very hard.

A coat of white lead and oil paint will give added protection and a surface that can be easily washed off.

The following tables give the number of square feet of stock required and length to cut stock for covering pipe with asbestos paper, ¾-inch hair felt and canvas:

SQUARE FEET OF STOCK REQUIRED PER LINEAL FOOT OF PIPE.

Size pipe	1 in.	1¼ in.	1½ in.	2 in.	2½ in.
Asbestos paper, square foot	.48	.52	.60	.73	.85
¾-inch hair felt, square foot	.55	.67	.70	.85	1.05
Canvas, square foot	.87	.98	1.05	1.22	1.37

Size pipe	3 in.	3½ in.	4 in.	5 in.	6 in.
Asbestos paper, square foot	1.00	1.15	1.30	1.57	1.85
¾-inch hair felt, square foot	1.20	1.35	1.45	1.70	2.00
Canvas, square foot	1.57	1.73	1.90	2.20	2.33

LENGTH OF STOCK REQUIRED TO GO AROUND A PIPE IN INCHES.

Size pipe	1 in.	$1\frac{1}{4}$ in.	$1\frac{1}{2}$ in.	2 in.	$2\frac{1}{2}$ in.
Asbestos paper	$5\frac{3}{4}$	$6\frac{1}{4}$	$7\frac{1}{8}$	$8\frac{3}{4}$	$10\frac{1}{4}$
$\frac{3}{4}$ inch hair felt	$6\frac{5}{8}$	$8\frac{1}{8}$	$8\frac{3}{4}$	$10\frac{1}{4}$	$12\frac{3}{8}$
Canvas	$10\frac{1}{2}$	$11\frac{7}{8}$	$12\frac{5}{8}$	$14\frac{5}{8}$	$16\frac{1}{2}$
Size pipe	**3 in.**	**$3\frac{1}{2}$ in.**	**4 in.**	**5 in.**	**6 in.**
Asbestos paper	12	$13\frac{7}{8}$	$15\frac{5}{8}$	$18\frac{7}{8}$	$22\frac{3}{8}$
$\frac{3}{4}$-inch hair felt	$14\frac{3}{4}$	$16\frac{1}{4}$	$17\frac{3}{8}$	$20\frac{1}{2}$	24
Canvas	$18\frac{7}{8}$	$20\frac{3}{4}$	23	$26\frac{3}{8}$	28

THICKNESS AND WEIGHT OF ASBESTOS PIPE COVERING.

Inside Diameter of Pipe, In.	Thickness of Covering, In.	Weight of Covering per Lineal Foot, Ozs.	Inside Diameter of Pipe, In.	Thickness of Covering, In.	Weight of Covering per Lineal Foot, Ozs.
$\frac{1}{2}$	$\frac{7}{8}$	8	7	$1\frac{1}{4}$	55
$\frac{3}{4}$	$\frac{7}{8}$	9	8	$1\frac{1}{4}$	65
1	$\frac{7}{8}$	10	9	$1\frac{1}{4}$	75
$1\frac{1}{4}$	$\frac{7}{8}$	12	10	$1\frac{1}{4}$	85
$1\frac{1}{2}$	$\frac{29}{32}$	15	12	$1\frac{1}{2}$	120
2	$1\frac{1}{32}$	18	O.D.		
$2\frac{1}{2}$	$1\frac{1}{32}$	20	14	$1\frac{1}{2}$	140
3	$1\frac{1}{32}$	24	16	$1\frac{1}{2}$	170
$3\frac{1}{2}$	$1\frac{1}{32}$	26	18	$1\frac{1}{2}$	200
4	$1\frac{1}{8}$	30	20	$1\frac{1}{2}$	240
$4\frac{1}{2}$	$1\frac{1}{8}$	38	24	$1\frac{1}{2}$	280
5	$1\frac{1}{8}$	44	30	$1\frac{1}{2}$	350
6	$1\frac{1}{8}$	48			

Asbestos Plastic Cement. — The plastic asbestos is put up dry in sacks, of about 60 pounds each, and will cover about 40 square feet of surface one inch thick per sack.

Bronzing. — Allow 1 pound gold bronze for each 100 square feet radiation.

Allow $\frac{1}{2}$ pound aluminum bronze for each 100 square feet radiation.

Allow 1 quart bronze liquid for each 100 square feet radiation.

If a coat of priming paint is used, only about half the above quantities will be required.

Do not leave bronzing liquid uncorked when not in use, as when exposed to the air it thickens and becomes worthless.

Do not get any of the bronze in the liquid can, as even a small quantity turns the liquid green.

Use a clean mixing can and a clean brush if good work is desired.

Endeavor to cover surface with one stroke of the brush if possible; do not work it more than absolutely necessary.

Notes on Heating. — Each foot of gas burned requires about 8.5 cubic feet of air.

Each pint of oil burned requires about 150 cubic feet of air.

Each pound of candles burned requires about 160 cubic feet of air.

An average gas burner uses about 4 cubic feet of gas per hour.

The respiration of an adult person will vitiate about 500 cubic feet of air per hour, to which should be added the vitiation from other sources, such as illumination, heat from the body, etc. Each adult person will require a supply of about 1000 cubic feet of air per hour in ordinary rooms. The Laws of Massachusetts for the ventilation of school rooms is 30 cubic feet of fresh air per minute for each pupil. Thus the average room providing for 50 pupils would require 1500 cubic feet per minute or 90,000 cubic feet per hour. Contemplating a movement of the air at the rate of 5 feet per second, and supply and exhaust registers $2 \times 2\frac{1}{2}$ feet each, or an area of 5 square feet, would insure the desired result.

The commercial rating of low pressure steam and water boilers contemplate the use of standard cast iron radiators. The same number of square feet of radiating surface in coils increases the tax on the boiler from 15 to 20 per cent over a corresponding number of square feet of cast iron radiation, and is estimated to be of corresponding greater value in heating.

The commercial ratings of low pressure steam boilers are based on a pressure of 2 pounds of steam (219 degrees) and of water boilers an average temperature of 170 in their maximum service. Systems of heating that provide for higher pressure and temperatures must have larger boilers provided.

Where radiators do not heat clear through, it is due to one of three causes:

First. An insufficient head of steam to expel the air from the radiator, or an insufficient volume of steam. As, for example, when running without any apparent pressure on the gauge.

Second. Traps in the pipe, which fill with water and prevent the steam from entering the radiator.

Third. Defective air valves, which sometimes become water sealed, or become filled with dirt, so that the air cannot escape.

No radiator should be placed less than two feet above the water line of the boiler.

Every heater of boiler should be "blown off" under pressure after drawing the fire, to thoroughly empty it of all grease and dirt after the first firing.

Locate the expansion tank of a hot water system in a convenient and accessible place, where there will be no danger of freezing, and where it will be well above the highest radiator. Connect the bottom opening with the return with not less than a 1 inch pipe.

There should be no stop valve between the tank and the boiler. It should have a 1 inch overflow pipe leading if convenient to the cellar near the heater, or if it is taken to the outside it should be so arranged that there will be no danger of freezing.

Combustion of Coal. — When coal is exposed to heat in a furnace, a portion of the carbon and hydrogen, associated in various chemical unions, as hydrocarbons, are volatilized and passed off. At the lowest temperature, naphthaline, resins and fluids with boiling-points are disengaged; and still higher, olefiant gas, followed by common gas, light carburetted hydrogen, which continues to be given off after the coal has reached a low red heat. What remains after the distilatory process is over is coke, which is the fixed or solid carbon of coal, with earthy matter, the ash of the coal.

Taking the fixed carbon, or coke remaining in the furnace after the volatile elements are distilled off, for round numbers at 60 per cent, the following is an approximate summary of the condition of the elements of average coal, after having been decomposed, and prior to entering into combustion.

100 Pounds of Average Coal in the Furnace.

Composition.	Lbs.
(Fixed)	60
Carbon (Volatilized)	20
Hydrogen	5
Sulphur	1 1-4
Oxygen	8
Nitrogen	1 1-5
Ash	4
About	100

Decomposition.	Lbs.
Fixed Carbon	60
Hydro-carbons	24
Sulphur	1 1-4
Water or Steam	9
Nitrogen	1 1-5
Ash	4
	100

Showing a total useful combustible of 86¼ per cent, of which 26¼ per cent is volatilized. While the decomposition proceeds, combustion proceeds, and the 26¼ per cent of volatilized portions, and the 60 per cent of fixed carbon successively are burned.

COAL may be arranged in five classes.

1. Anthracite, or blind coal, consisting almost entirely of free carbon.

2. Dry bituminous coal, having 70 to 80 per cent of carbon.

3. Bituminous caking coal, having 50 to 60 per cent of carbon.

4. Long flaming or cannel coal, having from 70 to 85 per cent of carbon.

5. Lignite, or brown coal, containing from 56 to 76 per cent of carbon.

In the United States a long ton of coal is 2240 pounds.

In the United States a short ton of coal is 2000 pounds.

In Illinois, Kentucky and Missouri 80 pounds of bituminous coal make a bushel.

In Pennsylvania 76 pounds of bituminous coal make a bushel.

In Indiana 70 pounds of bituminous coal make a bushel.

A cubic foot of solid anthracite coal weighs 93.5 pounds.

Forty-two cubic feet of prepared anthracite coal weigh one long ton.

TO TEST A HEATING SYSTEM.—An approximate test of a heating system may be made by using the following table which will indicate an efficiency in the plant to heat the building to 70 degrees when the external temperature is zero.

When external temperature is – 10, plant should heat building to 64.7.

When external temperature is 0, plant should heat building to 70.0.

When external temperature is 10, plant should heat building to 75.1.

When external temperature is 20, plant should heat building to 81.1.

When external temperature is 30, plant should heat building to 86.5.

When external temperature is 40, plant should heat building to 93.1.

When external temperature is 50, plant should heat building to 98.7.

When external temperature is 60, plant should heat building to 104.7.

When external temperature is 70, plant should heat building to 110.5.

The above is only approximate and when used the character and construction of the building must be taken into consideration.

PIPING OF HEATING SYSTEMS.

Piping Rules. — When installing the piping for any system of steam or hot water heating, the following rules should be observed.

Use as few mains as is consistent with the work. Large mains from which branches are taken are preferable to separate flow and return pipes to each radiator. The larger main of equal area to smaller ones has less friction and lesser radiating or condensing surface in the basement.

It is most desirable that the greatest distance possible be maintained between the water line of the boiler and the lowest and most remote distributing main or branch. Mr. Baldwin says: "It should never be less than 4 feet." While that distance is desirable, in some cases it is impossible to get this distance, and a lesser distance might work well especially if the main is not of an exceptionally long length.

The greatest care should be used in running the pipes. Carelessness or the work of an inexperienced workman may cause serious trouble. The pipes must be kept in perfect alignment and have a uniform grade so there will be no "traps" or pockets to hold the water and obstruct the circulation, and cause "hammering."

All horizontal branches should be one size larger than the riser which they are to supply, on account of the greater resistance to the flow as compared to the vertical riser.

Risers should not be less than $1\frac{1}{4}$ inch, no matter what the services may be to which they contribute. Mains and branches should be of ample size for the radiation they are to supply, with due allowance for their lengths.

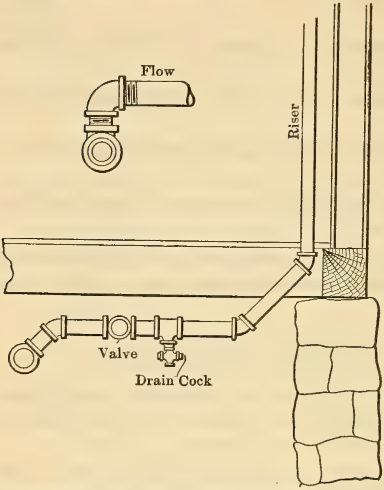


Fig. 26. Method of taking Branches from Main.

Too small pipes will often cause the radiators to fill with the water of condensation which cannot return until there is no pressure of steam, causing material variation in the water line of the boiler besides the efficiency of the radiator affected. Too small piping has spoilt many an otherwise good system of heating, something large piping never does. For size of mains, etc., see page 45.

It is desirable that an equalizing pipe connecting the steam mains near the boiler to the return connection be placed on all boilers, as it will overcome the trouble often experienced as the result of greasy or impure water, or that which is heavily charged with minerals peculiar to certain localities, and causing a foamy condition of the water.

Piping of One Pipe Single System.— In this system, as shown by Fig. 16, page 13, there is but one line of pipe to each radiator, or series of radiators, that can be supplied from one riser. The main and all pipes must have as much fall as possible towards the boiler, and at a point near the boiler the main should be relieved and the return condensation carried to the return inlet of the boiler.

In this system the steam supply passes upward and the condensation passes downward to the boiler in the same pipe.

Piping of One Pipe Circuit System. — In piping for this system, as shown by Fig. 17, page 14, the main should be

taken to the highest point of the basement above the boiler and then with considerable pitch downward (not less than $\frac{1}{2}$ inch in 10 feet) make a circuit of the building, returning and connecting with the boiler below the water line. The branches and risers should be taken from the top or side of the main, as shown by Fig. 26, and extreme care should be used to give all horizontal runs of pipe a fall back to the main or riser and to insure no pockets being in the line.

Fig. 27 illustrates the best way to take a branch from the end of a main. The end connection should turn up as shown and the pipe run at the same level as the other branches.

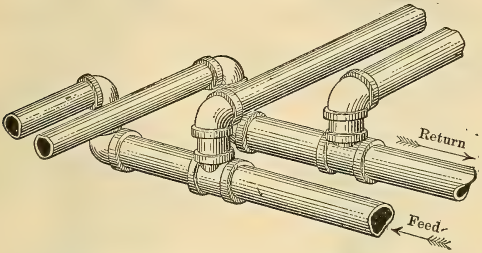


Fig. 27. Branch Connections at end of Main.

The main of a one pipe circuit system should be the same size its entire length, except where it drops to the boiler on the return, where it may be reduced one or two sizes. In this system always place an automatic air valve on the return end above the water line.

In this system there should be no noise when in operation, as the steam and condensation in the main are flowing in the same direction.

One Pipe Relief System. — In this system the piping is done the same as for the one just described, with the addition of a return main in the basement to carry back the condensation to the boiler, as shown by Fig. 18, page 15.

The supply main of this system may be reduced in size as the branches and risers are taken off, and at each point of reduction there should be a relief connection to the return main. The return or relieving main should be placed below the water line as shown, and each riser should have a relief connection to this return main to carry back the condensation.

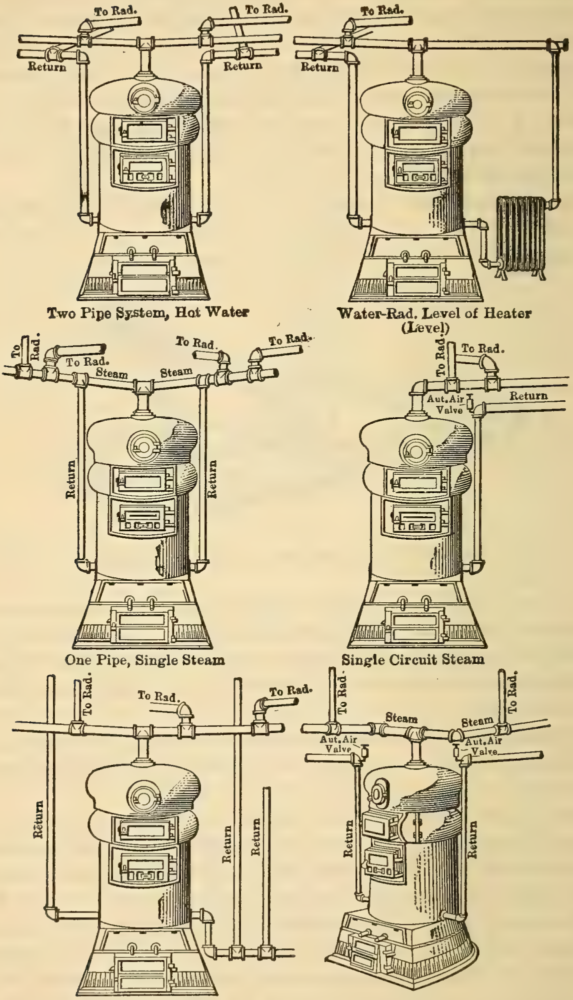


Fig. 28. Connections to Boiler.

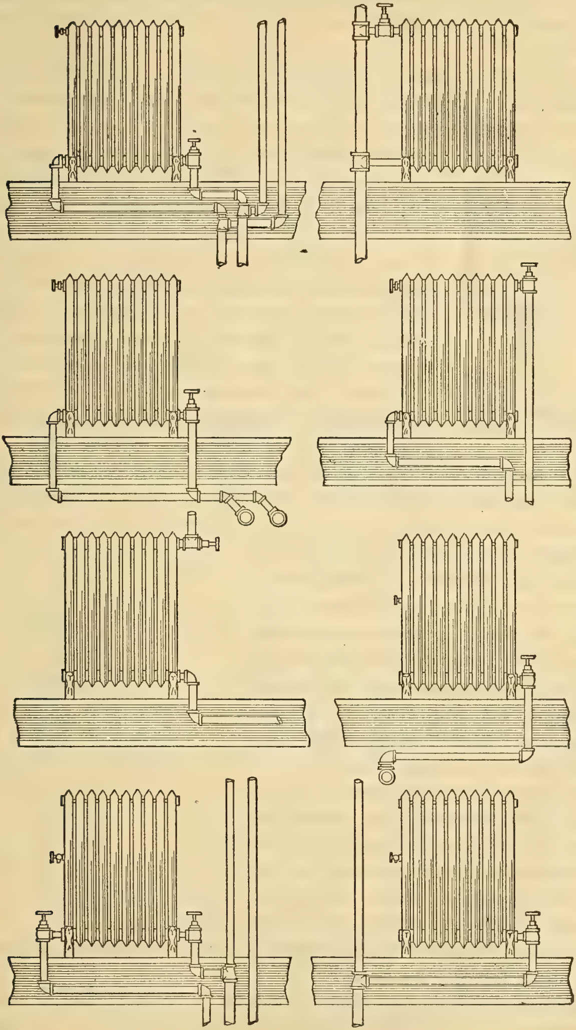


Fig. 29. Connections to Radiators.

Any system of heating having a horizontal return main below the water of the boiler is known as a "sealed" or "wet" return system.

If the return main is above the water line of the boiler it is known as a "dry" or "open" return, and if the return main is below the water line it is known as a "wet" or "sealed" return.

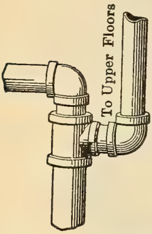


Fig. 30. Special Riser Connection.

Two Pipe System. — In the two pipe system, as shown by Fig. 20, page 16, there are two mains, one being a supply and one a return, and two separate pipes leading to and from the radiators, one being the supply and one the return leading to the return main.

The same care as to inclination of pipes, etc., should be exercised when installing this system as with those previously explained.

Piping, Connections, etc. — The methods of making the connections to the boiler for the different systems are shown by Fig. 28.

All the mains and risers of a heating system should be run as direct and with as few fittings as possible. The horizontal runs from the riser to the radiators should be as short as possible, and should have a good fall toward the riser. Fig. 29 shows different methods of connecting up radiators, and Fig. 30 shows a riser connection which will favor or give advantage to the lower radiator, as the greater amount of steam or water will pass up into the branch rather than enter the riser to the next floor.

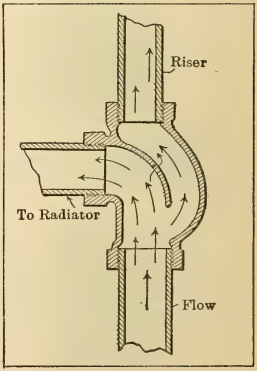


Fig. 31. "O and S" Distributer.

A special fitting, known as the "O. S. Distributer," as shown by Fig. 31, can also be used to advantage when taking branches off a riser.

The partition in the fitting, as shown, splits or divides the flow of steam or water, taking what is required for the lower radiator.

Another riser fitting, as shown by Fig. 32 and Fig. 33, is manufactured by A. Y. McDonald & Morrison Mfg. Co., Dubuque, Iowa. It is designed to be used either in steam or hot water

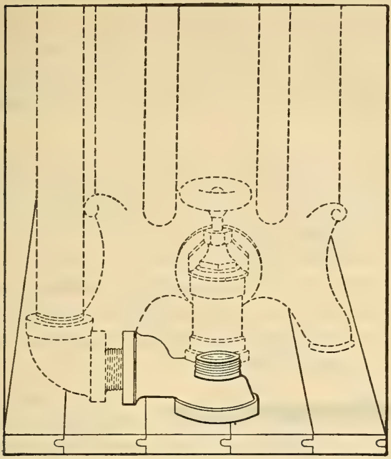


Fig. 32. Special Radiator Riser Fitting.

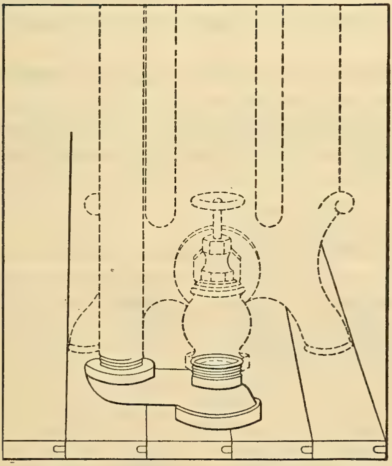


Fig. 33. Special Radiator Riser Fitting.

heating, where the radiators set one above the other on different floors. The branch water-way is larger than the pipes leading from it, thus doing away with any possible friction.

Style A, as shown by Fig. 32, can be used when the radiator does not set directly over the lower radiator by using a nipple and elbow.

Style B, as shown by Fig. 33, is used when the radiators are placed directly over each other and it is the right distance between the valve opening and outlet opening so that it will be away from the wall and base-board.

This fitting also gives favor to the lower radiator.

Reaming. — The ends of all pipes in a heating system, either steam or hot water, should be reamed out as shown by Fig. 34 to remove all the sharp burs or edges and give an unobstructed passage to the steam or water.

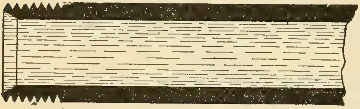


Fig. 34. Reamed End of Pipe.

In cutting the pipe, especially when cut with a wheel cutter, the pressure of the wheel in cutting forms a bur on the inside of the pipe that diminishes the area of the pipe considerably, and if this bur is not removed the full value of the pipe is not obtained.

Size of Returns. — The return pipes of a steam heating system are usually run one size smaller than the supply pipes, and it is a good rule for the smaller sizes of pipes, but for the larger sizes it can be reduced two or more sizes smaller than the supply. The following table gives the size of returns suitable for the different sizes of supply mains.

SIZES OF RETURNS FOR STEAM HEATING SYSTEMS.

Diameter of Steam Supply Pipe.	Diameter of Pipe for Dry Return.	Diameter of Pipe for Wet Return.	Diameter of Steam Supply Pipe.	Diameter of Pipe for Dry Return.	Diameter of Pipe for Wet Return.
1	1	¾	5	3	2½
1¼	1	1	6	3½	3
1½	1¼	1	7	3½	3
2	1½	1¼	8	4	3½
2½	2	1½	9	5	3½
3	2½	2	10	5	4
3½	2½	2	12	6	5
4	3	2½			

Connection of Wall Radiators. — When both the supply and return pipes are below the radiator, they should both be connected at the lower corners of the radiator, but if the supply is above the radiator then it should be connected at the upper corner of the radiator, and the return at the lower opposite corner.

Expansion of Pipes. — When installing a heating system for either steam or hot water special attention must be given to the question of expansion in the pipes, especially if there are any long runs or risers in the system. In long risers an expansion loop can be arranged in the pipe as shown by Fig. 35; this loop can be put in at a floor where it will be concealed from view, then the two ends of the riser can be anchored solid and the loop will take care of all expansion.

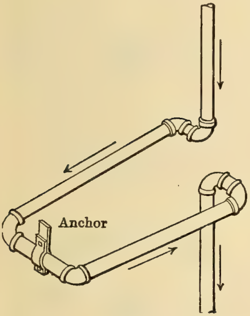


Fig. 35. Riser Expansion Loop.

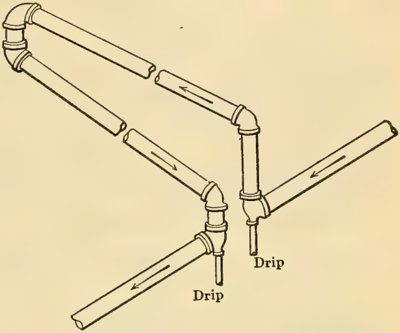


Fig. 36. Expansion Loop in Main.

A like arrangement, as shown by Fig. 36, can be put in a long main or horizontal run of pipe.

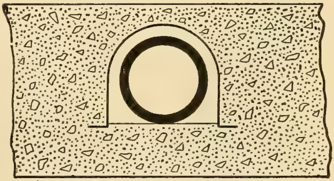


Fig. 37. Metal Pipe Cover in Concrete.

The main object to have in view to take care of the expansion in a run of pipes is to have all pipes and fittings so arranged that the expansion of the pipes will only tend to turn the fittings on their threads. For table of expansion of pipes see page 45.

When horizontal branches or runs of pipes run through a concrete floor they should be covered with a sheet metal cover, as shown by Fig. 37, to keep the pipe free from the concrete and allow for a movement of the pipe caused by expansion.

Pipe Bends. — Pipe bends are now being made to take the place of fittings, and also to allow for expansion in the pipes. A number of these bends, as manufactured by Crane Co., are shown by Figs. 38–50.

SIZE AND RADII OF PIPE BENDS.

	In Inches.									
Size of bend	2½	3	3½	4	4½	5	6	7	8	9
Radii recommended	12½	15	17½	20	22½	25	30	35	40	45
Shortest length of straight pipe necessary on each end	4	4	5	5	6	6	7	8	9	11
Size of bend	10	12	14	15	16	18	20	22	24	
Radii recommended	50	60	70	75	80	108	120	132	144	
Shortest length of straight pipe necessary on each end	12	14	16	16	20	22	24	28	32	

MALLEABLE AND CAST IRON PIPE FITTINGS.

Fig. 51 and Fig. 52 show the shape and style of the various malleable and cast iron pipe fittings. Their names are as follows: —

1. Elbow.
2. 45 degree elbow.
3. Street ell.
4. Drop ell, female.
5. Side outlet ell.
6. Reducing ell.
7. Double branch ell.
8. Long male ell.
9. Drop ell, right hand flange.
10. Drop ell, left hand flange.
11. Tee.
12. 4 way tee.
13. Drop tee, female.
14. Cross.
15. Cross over.
16. Cross over with face outlet.

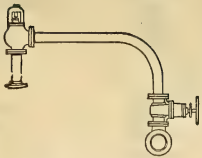


Fig.38-Boiler and header connection

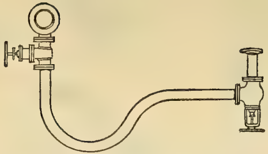


Fig.39-Boiler and header connection when header is higher than in Fig. 38

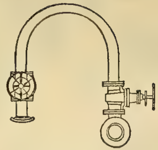


Fig.40-Boiler and header connection with a U bend

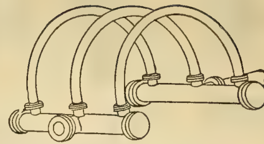


Fig. 41-Battery of three 8-inch U bends connected to headers and placed in 14-inch main steam line to take care of expansion and contraction. This combination is preferable to a U bend the full size of the pipe because of its greater flexibility

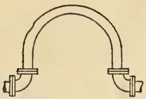


Fig.42-U bend located in a straight run to allow for expansion

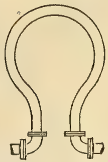


Fig.43-Modification of Fig.42 for limited center to center spaces

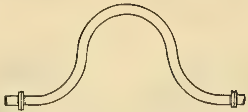


Fig.44-Expansion loop in straight line. If made in a single piece, can be used only in 8-inch or smaller sizes

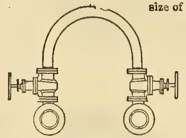


Fig.45-U bend cross-connecting two parallel headers

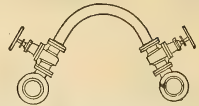


Fig.46-Modification of Fig.45 for special conditions. This form entails some loss in flexibility

Fig.47-Offset band. This is sometimes made compound, that is, offsetting upwards and to one side

Fig.48-Crossover bend. Used when necessary to avoid other pipes, pillars, etc.

Fig.49--45° bend

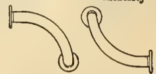


Fig.50-Compound quarter bend to suit local conditions

Common Forms of Pipe Bends.

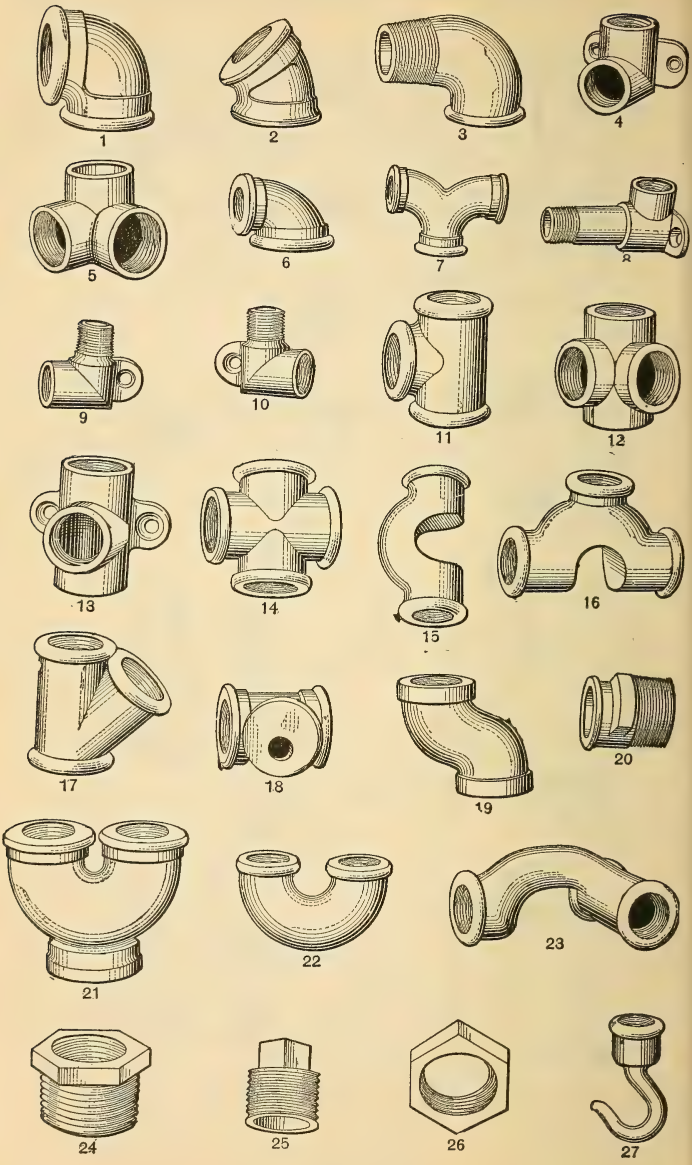


Fig. 51. Pipe Fittings.

17. Y branch.
18. Eccentric tee.
19. Offset.
20. Offset reducing. Coupling.
21. Return bend, back outlet.
22. Return bend.
23. Cross over tee.
24. Bushing.
25. Plug.
26. Locknut.
27. Chandelier hook, female.
28. Eccentric tee.
29. Eccentric reducer.
30. Tee reducer on run.
31. Coupling reducer.
32. Tee cross over.
33. Nipple.
34. Cap.
35. Union.
36. Ell with female union.
37. Double Y branch.
38. Ell with male union.

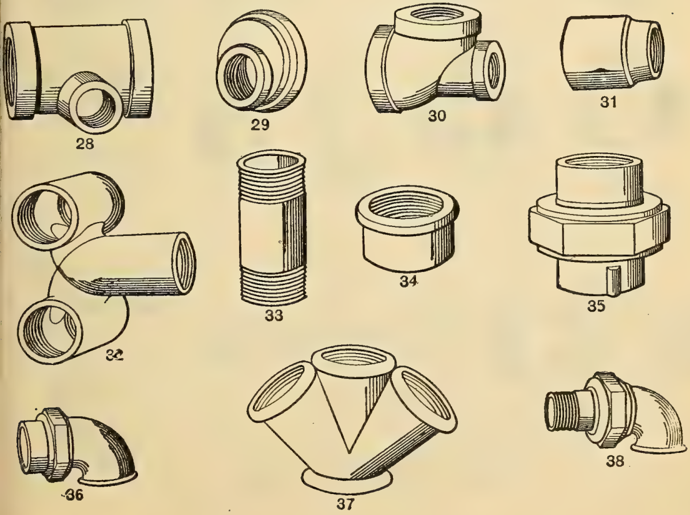


Fig. 51. Pipe Fittings. — *Continued.*

Iron Railing Fittings.

39. Elbow.
40. Side outlet ell.
41. Tee.
42. Side outlet tee.
43. Cross.
44. Side outlet cross.
45. Ornament.
46. Bushing.
47–48. Flanges.
49. Pipe gate hinge.
50. Latch for pipe gate.
51. Hand rail tee, adjustable.

MALE FITTING. — A male fitting is one that screws into another fitting or opening.

FEMALE FITTING. — A female fitting is one that screws onto a pipe, nipple, or another fitting.

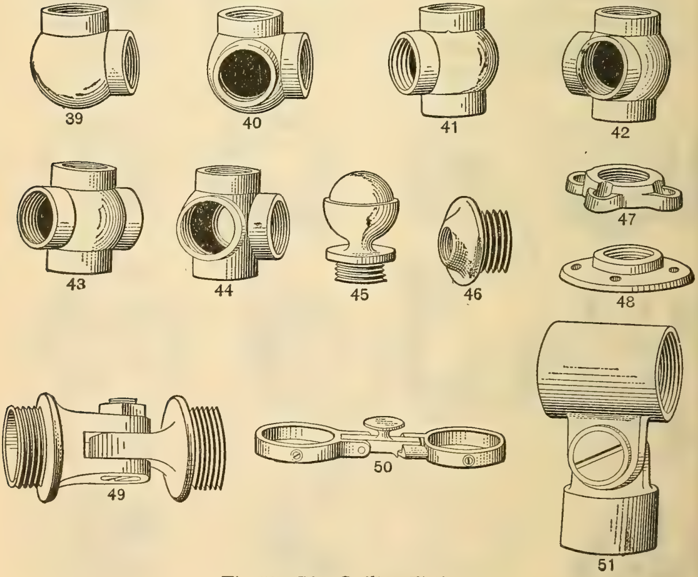


Fig. 52. Pipe Railing Fittings.

STANDARD SIZES OF MALLEABLE FITTINGS.

Elbows.

$\frac{1}{8}$	P
$\frac{1}{4}\times\frac{1}{8}$	P
*$\frac{1}{4}$	P & B
$\frac{3}{8}\times\frac{1}{8}$	P
*$\frac{3}{8}\times\frac{1}{4}$	P & B
*$\frac{3}{8}$	B
$\frac{1}{2}\times\frac{1}{4}$	B
*$\frac{1}{2}\times\frac{3}{8}$	P & B
*$\frac{1}{2}$	P & B
*$\frac{3}{4}\times\frac{3}{8}$	P & B
*$\frac{3}{4}\times\frac{1}{2}$	P & B
*$\frac{3}{4}$	P & B
$1\times\frac{3}{8}$	P & B
*$1\times\frac{1}{2}$	P & B
*$1\times\frac{3}{4}$	P & B
*1	P & B
$1\frac{1}{4}\times\frac{3}{4}$	P & B
*$1\frac{1}{4}\times1$	P & B
*$1\frac{1}{4}$	P & B
$1\frac{1}{2}\times\frac{3}{4}$	P & B
$1\frac{1}{2}\times1$	P & B
*$1\frac{1}{2}\times1\frac{1}{4}$	P & B
*$1\frac{1}{2}$	P & B
$2\times\frac{3}{4}$	P
2×1	P & B
$2\times1\frac{1}{4}$	P & B
*$2\times1\frac{1}{2}$	P & B
*2	P & B
$2\frac{1}{2}\times1\frac{1}{2}$	B
$2\frac{1}{2}\times2$	B
*$2\frac{1}{2}$	P & B
3×2	B
$3\times2\frac{1}{2}$	B
*3	P & B
$3\frac{1}{2}\times3$	B
$3\frac{1}{2}$	B
4×3	B
$4\times3\frac{1}{2}$	B
*4	B
$4\frac{1}{2}$	B
5	B
6	B

Street Ells.

$\frac{1}{4}$	B
*$\frac{3}{8}$	B
*$\frac{1}{2}$	B
$\frac{3}{4}\times\frac{1}{2}$	B
*$\frac{3}{4}$	B
$1\times\frac{3}{4}$	B
*1	B
*$1\frac{1}{4}\times1$	B
$1\frac{1}{4}\times\frac{3}{4}$	B
*$1\frac{1}{4}$	B
$1\frac{1}{2}\times1$	B
$1\frac{1}{2}\times1\frac{1}{4}$	B
*$1\frac{1}{2}$	B
2×1	B
$2\times1\frac{1}{4}$	B
$2\times1\frac{1}{2}$	B
*2	B
$2\frac{1}{2}$	B
$2\frac{1}{2}\times2$	B
$2\frac{1}{2}\times1\frac{1}{2}$	B
3	B

Side Outlet Elbows.

*$\frac{3}{8}\times\frac{3}{8}\times\frac{3}{8}$	P
$\frac{1}{2}\times\frac{1}{2}\times\frac{3}{8}$	P
*$\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}$	P
$\frac{3}{4}\times\frac{3}{4}\times\frac{3}{8}$	P
$\frac{3}{4}\times\frac{3}{4}\times\frac{1}{2}$	P
*$\frac{3}{4}\times\frac{3}{4}\times\frac{3}{4}$	P
$1\times1\times\frac{3}{8}$	P
$1\times1\times\frac{1}{2}$	P
$1\times1\times\frac{3}{4}$	P
*$1\times1\times1$	P
$1\frac{1}{4}\times1\frac{1}{4}\times1$	P
$1\frac{1}{4}\times1\frac{1}{4}\times1\frac{1}{4}$	P
*$1\frac{1}{2}\times1\frac{1}{2}\times1\frac{1}{2}$	P
$2\times2\times2$	P

Drop Ells.
Female.

$\frac{1}{4}\times\frac{1}{4}$	P
$\frac{3}{8}\times\frac{1}{4}$	P
*$\frac{3}{8}\times\frac{3}{8}$	P
$\frac{1}{2}\times\frac{3}{8}$	P
*$\frac{1}{2}\times\frac{1}{2}$	P
*$\frac{3}{4}\times\frac{1}{2}$	P
*$\frac{3}{4}\times\frac{3}{4}$	P
*1×1	P

Tees.

$\frac{1}{8}\times\frac{1}{8}\times\frac{1}{8}$	P
$\frac{1}{8}\times\frac{1}{8}\times\frac{1}{4}$	P
$\frac{1}{4}\times\frac{1}{8}\times\frac{1}{8}$	P
$\frac{1}{4}\times\frac{1}{4}\times\frac{1}{8}$	P
*$\frac{1}{4}\times\frac{1}{4}\times\frac{1}{4}$	P & B
*$\frac{1}{4}\times\frac{1}{4}\times\frac{3}{8}$	P & B
$\frac{3}{8}\times\frac{1}{4}\times\frac{1}{4}$	P
$\frac{3}{8}\times\frac{1}{4}\times\frac{3}{8}$	P
$\frac{3}{8}\times\frac{3}{8}\times\frac{1}{8}$	P
*$\frac{3}{8}\times\frac{3}{8}\times\frac{1}{4}$	P
*$\frac{3}{8}\times\frac{3}{8}\times\frac{3}{8}$	P & B
*$\frac{3}{8}\times\frac{3}{8}\times\frac{1}{2}$	P & B
$\frac{1}{2}\times\frac{3}{8}\times\frac{1}{4}$	P
*$\frac{1}{2}\times\frac{3}{8}\times\frac{3}{8}$	P & B
$\frac{1}{2}\times\frac{1}{4}\times\frac{1}{2}$	P
*$\frac{1}{2}\times\frac{3}{8}\times\frac{1}{2}$	P & B
$\frac{1}{2}\times\frac{3}{8}\times\frac{3}{4}$	P & B
$\frac{1}{2}\times\frac{1}{2}\times\frac{1}{4}$	P & B
*$\frac{1}{2}\times\frac{1}{2}\times\frac{3}{8}$	P & B
*$\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}$	P & B
*$\frac{1}{2}\times\frac{1}{2}\times\frac{3}{4}$	P & B
$\frac{3}{4}\times\frac{1}{4}\times\frac{3}{4}$	P
*$\frac{3}{4}\times\frac{3}{8}\times\frac{3}{8}$	P & B
*$\frac{3}{4}\times\frac{3}{8}\times\frac{1}{2}$	P
*$\frac{3}{4}\times\frac{3}{8}\times\frac{3}{4}$	P & B
$\frac{3}{4}\times\frac{3}{8}\times1$	P
$\frac{3}{4}\times\frac{1}{2}\times\frac{1}{4}$	P
*$\frac{3}{4}\times\frac{1}{2}\times\frac{3}{8}$	P & B
*$\frac{3}{4}\times\frac{1}{2}\times\frac{1}{2}$	P & B
*$\frac{3}{4}\times\frac{1}{2}\times\frac{3}{4}$	P & B
*$\frac{3}{4}\times\frac{1}{2}\times1$	P & B
$\frac{3}{4}\times\frac{3}{4}\times\frac{1}{4}$	P & B
*$\frac{3}{4}\times\frac{3}{4}\times\frac{3}{8}$	P & B
*$\frac{3}{4}\times\frac{3}{4}\times\frac{1}{2}$	P & B
*$\frac{3}{4}\times\frac{3}{4}\times\frac{3}{4}$	P & B
*$\frac{3}{4}\times\frac{3}{4}\times1$	P & B

Tees.—*Continued.*

$\frac{3}{4}\times\frac{3}{4}\times1\frac{1}{4}$	B
$1\times\frac{3}{8}\times\frac{1}{2}$	P
$1\times\frac{3}{8}\times\frac{3}{4}$	P
$1\times\frac{3}{8}\times1$	P & B
*$1\times\frac{1}{2}\times\frac{1}{2}$	P & B
*$1\times\frac{1}{2}\times\frac{3}{4}$	B
*$1\times\frac{1}{2}\times1$	P & B
*$1\times\frac{3}{4}\times\frac{3}{8}$	P & B
*$1\times\frac{3}{4}\times\frac{1}{2}$	P & B
*$1\times\frac{3}{4}\times\frac{3}{4}$	P & B
*$1\times\frac{3}{4}\times1$	P & B
*$1\times\frac{3}{4}\times1\frac{1}{4}$	P & B
$1\times1\times\frac{1}{4}$	P & B
*$1\times1\times\frac{3}{8}$	P & B
*$1\times1\times\frac{1}{2}$	P & B
*$1\times1\times\frac{3}{4}$	P & B
*$1\times1\times1$	P & B
*$1\times1\times1\frac{1}{4}$	P & B
$1\times1\times1\frac{1}{2}$	P & B
$1\frac{1}{4}\times\frac{3}{8}\times1\frac{1}{4}$	P & B
$1\frac{1}{4}\times\frac{1}{2}\times1$	P & B
*$1\frac{1}{4}\times\frac{1}{2}\times1\frac{1}{4}$	P & B
$1\frac{1}{4}\times\frac{3}{4}\times\frac{3}{4}$	P & B
*$1\frac{1}{4}\times\frac{3}{4}\times1$	P & B
*$1\frac{1}{4}\times\frac{3}{4}\times1\frac{1}{4}$	P & B
$1\frac{1}{4}\times1\times\frac{3}{8}$	P & B
*$1\frac{1}{4}\times1\times\frac{1}{2}$	P & B
*$1\frac{1}{4}\times1\times\frac{3}{4}$	P & B
*$1\frac{1}{4}\times1\times1$	P & B
*$1\frac{1}{4}\times1\times1\frac{1}{4}$	P & B
$1\frac{1}{4}\times1\times1\frac{1}{2}$	B
$1\frac{1}{4}\times1\frac{1}{4}\times\frac{3}{8}$	P & B
*$1\frac{1}{4}\times1\frac{1}{4}\times\frac{1}{2}$	P & B
*$1\frac{1}{4}\times1\frac{1}{4}\times\frac{3}{4}$	P & B
*$1\frac{1}{4}\times1\frac{1}{4}\times1$	P & B
*$1\frac{1}{4}\times1\frac{1}{4}\times1\frac{1}{4}$	P & B
*$1\frac{1}{4}\times1\frac{1}{4}\times1\frac{1}{2}$	P & B
$1\frac{1}{4}\times1\frac{1}{4}\times2$	P & B
$1\frac{1}{2}\times\frac{3}{8}\times1\frac{1}{2}$	B
$1\frac{1}{2}\times\frac{1}{2}\times1\frac{1}{2}$	P & B
$1\frac{1}{2}\times\frac{3}{4}\times1\frac{1}{4}$	B
$1\frac{1}{2}\times\frac{3}{4}\times1\frac{1}{2}$	P & B
$1\frac{1}{2}\times1\times\frac{3}{4}$	B
*$1\frac{1}{2}\times1\times1$	P & B
*$1\frac{1}{2}\times1\times1\frac{1}{4}$	B
*$1\frac{1}{2}\times1\times1\frac{1}{2}$	P & B
*$1\frac{1}{2}\times1\frac{1}{4}\times\frac{3}{4}$	B
*$1\frac{1}{2}\times1\frac{1}{4}\times1$	B
*$1\frac{1}{2}\times1\frac{1}{4}\times1\frac{1}{4}$	P & B
*$1\frac{1}{2}\times1\frac{1}{4}\times1\frac{1}{2}$	P & B
$1\frac{1}{2}\times1\frac{1}{2}\times\frac{3}{8}$	B
$1\frac{1}{2}\times1\frac{1}{2}\times\frac{1}{2}$	P & B
*$1\frac{1}{2}\times1\frac{1}{2}\times\frac{3}{4}$	P & B
*$1\frac{1}{2}\times1\frac{1}{2}\times1$	P & B
*$1\frac{1}{2}\times1\frac{1}{2}\times1\frac{1}{4}$	P & B
*$1\frac{1}{2}\times1\frac{1}{2}\times1\frac{1}{2}$	P & B
*$1\frac{1}{2}\times1\frac{1}{2}\times2$	P & B
$2\times\frac{3}{8}\times2$	B
$2\times\frac{1}{2}\times2$	P & B
$2\times\frac{3}{4}\times2$	P & B
$2\times1\times2$	P & B
*$2\times1\frac{1}{4}\times1\frac{1}{4}$	P & B
$2\times1\frac{1}{4}\times1\frac{1}{2}$	P & B
$2\times1\frac{1}{4}\times2$	P & B
$2\times1\frac{1}{2}\times\frac{3}{4}$	B

Tees.—*Continued.*

$2\times1\frac{1}{4}\times1$	B
*$2\times1\frac{1}{2}\times1\frac{1}{4}$	P & B
*$2\times1\frac{1}{2}\times1\frac{1}{2}$	P & B
*$2\times1\frac{1}{2}\times2$	P & B
*$2\times2\times\frac{1}{2}$	P & B
*$2\times2\times\frac{3}{4}$	P & B
*$2\times2\times1$	P & B
*$2\times2\times1\frac{1}{4}$	P & B
*$2\times2\times1\frac{1}{2}$	P & B
*$2\times2\times2$	P & B
$2\times2\times2\frac{1}{2}$	B
*$2\frac{1}{2}\times2\frac{1}{2}\times1$	B
$2\frac{1}{2}\times2\frac{1}{2}\times1\frac{1}{4}$	B
$2\frac{1}{2}\times2\frac{1}{2}\times1\frac{1}{2}$	B
*$2\frac{1}{2}\times2\frac{1}{2}\times2$	P & B
*$2\frac{1}{2}\times2\frac{1}{2}\times2\frac{1}{2}$	P & B
$3\times3\times1$	B
$3\times3\times1\frac{1}{4}$	B
$3\times3\times1\frac{1}{2}$	B
*$3\times3\times2$	P & B
*$3\times3\times2\frac{1}{2}$	B
*$3\times3\times3$	P & B
$3\frac{1}{2}\times3\frac{1}{2}\times2$	B
$3\frac{1}{2}\times3\frac{1}{2}\times2\frac{1}{2}$	B
$3\frac{1}{2}\times3\frac{1}{2}\times3$	B
$3\frac{1}{2}\times3\frac{1}{2}\times3\frac{1}{2}$	B
$4\times4\times2$	B
$4\times4\times2\frac{1}{2}$	B
$4\times4\times3$	B
$4\times4\times3\frac{1}{2}$	B
*$4\times4\times4$	B
$4\frac{1}{2}\times4\frac{1}{2}\times4\frac{1}{2}$	B
$5\times5\times5$	B
$6\times6\times6$	B

Tees.
Long Drop.

$\frac{3}{8}\times\frac{3}{8}\times$	P

Tees.
Drop Female.

$\frac{3}{8}\times\frac{1}{4}\times\frac{1}{4}$	P
$\frac{3}{8}\times\frac{3}{8}\times\frac{1}{4}$	P
*$\frac{3}{8}\times\frac{3}{8}\times\frac{3}{8}$	P
$\frac{1}{2}\times\frac{1}{4}\times\frac{1}{2}$	P
$\frac{1}{2}\times\frac{3}{8}\times\frac{1}{4}$	P
$\frac{1}{2}\times\frac{3}{8}\times\frac{3}{8}$	P
$\frac{1}{2}\times\frac{1}{2}\times\frac{1}{4}$	P
*$\frac{1}{2}\times\frac{1}{2}\times\frac{3}{8}$	P
*$\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}$	P
$\frac{3}{4}\times\frac{1}{2}\times\frac{1}{4}$	P
$\frac{3}{4}\times\frac{1}{2}\times\frac{3}{8}$	P
*$\frac{3}{4}\times\frac{3}{4}\times\frac{1}{4}$	P
*$\frac{3}{4}\times\frac{3}{4}\times\frac{3}{8}$	P
*$\frac{3}{4}\times\frac{3}{4}\times\frac{1}{2}$	P
*$\frac{3}{4}\times\frac{3}{4}\times\frac{3}{4}$	P
$1\times\frac{3}{4}\times\frac{3}{8}$	P
$1\times1\times\frac{3}{8}$	P
$1\times1\times\frac{1}{2}$	P
$1\times1\times\frac{3}{4}$	P
$1\times1\times1$	P

STANDARD SIZES OF MALLEABLE FITTINGS.—*Continued.*

Tees.—*Continued.* *Drop.—M. & F.*

$\frac{1}{4}\times\frac{1}{4}\times\frac{3}{8}$	P
$\frac{3}{8}\times\frac{1}{4}\times\frac{3}{8}$	P
*$\frac{3}{8}\times\frac{3}{8}\times\frac{3}{8}$	P
$\frac{1}{2}\times\frac{3}{8}\times\frac{3}{8}$	P
*$\frac{1}{2}\times\frac{1}{2}\times\frac{3}{8}$	P
$\frac{3}{4}\times\frac{1}{2}\times\frac{3}{8}$	P
$\frac{3}{4}\times\frac{3}{4}\times\frac{3}{8}$	P
$1\times\frac{3}{4}\times\frac{3}{8}$	P
$1\times1\times\frac{3}{8}$	P

Crosses.

$\frac{1}{4}\times\frac{1}{4}\times\frac{1}{4}$	P
$\frac{3}{8}\times\frac{1}{4}\times\frac{1}{4}$	P
$\frac{3}{8}\times\frac{3}{8}\times\frac{1}{4}$	P
$\frac{3}{8}\times\frac{3}{8}\times\frac{3}{8}$	P
$\frac{1}{2}\times\frac{3}{8}\times\frac{1}{4}$	P
$\frac{1}{2}\times\frac{3}{8}\times\frac{3}{8}$	P
$\frac{1}{2}\times\frac{1}{2}\times\frac{1}{4}$	P
*$\frac{1}{2}\times\frac{1}{2}\times\frac{3}{8}$	P & B
*$\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}$	P & B
$\frac{3}{8}\times\frac{3}{8}\times\frac{1}{2}$	P
$\frac{3}{4}\times\frac{1}{2}\times\frac{3}{8}$	P
*$\frac{3}{4}\times\frac{1}{2}\times\frac{1}{2}$	P
$\frac{3}{4}\times\frac{3}{4}\times\frac{3}{8}$	P & B
*$\frac{3}{4}\times\frac{3}{4}\times\frac{1}{2}$	P & B
*$\frac{3}{4}\times\frac{3}{4}\times\frac{3}{4}$	P & B
$1\times\frac{3}{4}\times\frac{1}{2}$	P & B
$1\times\frac{3}{4}\times\frac{3}{4}$	P & B
$1\times1\times\frac{3}{8}$	P & B

Crosses.—*Continued.*

*$1\times1\times\frac{1}{2}$	P & B
*$1\times1\times\frac{3}{4}$	P & B
*$1\times1\times1$	P & B
$1\frac{1}{4}\times1\times\frac{3}{4}$	B
$1\frac{1}{4}\times1\times1$	B
$1\frac{1}{4}\times1\frac{1}{4}\times\frac{3}{8}$	B
*$1\frac{1}{4}\times1\frac{1}{4}\times\frac{1}{2}$	P & B
*$1\frac{1}{4}\times1\frac{1}{4}\times\frac{3}{4}$	P & B
*$1\frac{1}{4}\times1\frac{1}{4}\times1$	P & B
*$1\frac{1}{4}\times1\frac{1}{4}\times1\frac{1}{4}$	P & B
$1\frac{1}{2}\times1\frac{1}{4}\times1\frac{1}{4}$	B
$1\frac{1}{2}\times1\frac{1}{2}\times1\frac{1}{2}$	P & B
*$1\frac{1}{2}\times1\frac{1}{2}\times\frac{3}{4}$	P & B
*$1\frac{1}{2}\times1\frac{1}{2}\times1$	P & B
*$1\frac{1}{2}\times1\frac{1}{2}\times1\frac{1}{4}$	P & B
*$1\frac{1}{2}\times1\frac{1}{2}\times1\frac{1}{2}$	P & B
$2\times2\times\frac{1}{2}$	P & B
*$2\times2\times\frac{3}{4}$	P & B
*$2\times2\times1$	P & B
*$2\times2\times1\frac{1}{4}$	P & B
*$2\times2\times1\frac{1}{2}$	P & B
*$2\times2\times2$	P & B
$2\frac{1}{2}\times2\frac{1}{2}\times1\frac{1}{2}$	B
$2\frac{1}{2}\times2\frac{1}{2}\times2$	B
*$2\frac{1}{2}\times2\frac{1}{2}\times2\frac{1}{2}$	P & B
$3\times3\times2$	B
$3\times3\times2\frac{1}{2}$	B
$3\times3\times3$	B
$3\frac{1}{2}\times3\frac{1}{2}\times3\frac{1}{2}$	B
$4\times4\times2$	B
$4\times4\times4$	B

Reducers.

$\frac{1}{4}\times\frac{1}{8}$	P
$\frac{3}{8}\times\frac{1}{8}$	P
$\frac{3}{8}\times\frac{1}{4}$	P & B
$\frac{1}{2}\times\frac{1}{4}$	P
*$\frac{1}{2}\times\frac{3}{8}$	P & B
$\frac{3}{4}\times\frac{1}{4}$	P
$\frac{3}{4}\times\frac{3}{8}$	P
$\frac{3}{4}\times\frac{1}{2}$	P & B
$1\times\frac{1}{4}$	P
$1\times\frac{3}{8}$	P
*$1\times\frac{1}{2}$	P
*$1\times\frac{3}{4}$	P & B
$1\frac{1}{4}\times\frac{3}{8}$	P & B
*$1\frac{1}{4}\times\frac{1}{2}$	P & B
*$1\frac{1}{4}\times\frac{3}{4}$	P & B
*$1\frac{1}{4}\times1$	P & B
$1\frac{1}{2}\times\frac{3}{8}$	P & B
*$1\frac{1}{2}\times\frac{1}{2}$	P & B
*$1\frac{1}{2}\times\frac{3}{4}$	P & B
*$1\frac{1}{2}\times1$	P & B
*$1\frac{1}{2}\times1\frac{1}{4}$	P & B
$2\times\frac{1}{2}$	P & B
$2\times\frac{3}{4}$	P & B
*2×1	P & B
*$2\times1\frac{1}{4}$	P & B
*$2\times1\frac{1}{2}$	P & B
$2\frac{1}{2}\times1$	B
*$2\frac{1}{2}\times1\frac{1}{4}$	B
$2\frac{1}{2}\times1\frac{1}{2}$	P & B
*$2\frac{1}{2}\times2$	P & B
3×1	B
$3\times1\frac{1}{4}$	B

Reducers.—*Continued.*

*$3\times1\frac{1}{2}$	B
3×2	P & B
*$3\times2\frac{1}{2}$	P & B
$3\frac{1}{2}\times2\frac{1}{2}$	P & B
*$3\frac{1}{2}\times3$	P & B
4×2	P & B
*$4\times2\frac{1}{2}$	P & B
4×3	P & B
$4\times3\frac{1}{2}$	P & B

Extension Pieces.

$\frac{3}{8}\times\frac{3}{8}$	
$\frac{1}{2}\times\frac{1}{2}$	
$\frac{3}{4}\times\frac{3}{4}$	

Y Branches.

$\frac{1}{2}$	B
$\frac{3}{4}$	B
1	B
$1\frac{1}{4}$	P & B
$1\frac{1}{2}$	P & B
$1\frac{1}{2}\times1\frac{1}{4}$	P & B
2	P & B
$2\times1\frac{1}{2}\times1\frac{1}{2}$	P & B
$2\times1\frac{1}{4}$	P & B
$2\times1\frac{1}{2}$	P & B

Note.—The letter "P" following sizes indicates that Fittings are made in Plain pattern only; "B" indicates Beaded pattern; "P & B" indicates that they are made both Plain and Beaded. In ordering, be particular to state which pattern is wanted.

* Carried in stock, by Manufacturers, Galvanized.

PART II.

DATA ON BOILERS. MISCELLANEOUS INFORMATION FOR PLUMBERS AND STEAM-FITTERS. TABLES OF RADIATION. VARIOUS COMPUTATION TABLES. TABLES OF SIZES, STRENGTHS, ETC. TABLES OF WEIGHTS, ETC.

DATA ON BOILERS.

Selecting a Proper Size Boiler. — It is desirable and important that in selecting a heating apparatus the capacity should be somewhat beyond rather than below the actual requirements of the building, for these reasons:

First. It not only insures ample warmth at all times, but gives some reserve capacity to provide against exceptionally cold weather, or temporarily to furnish a higher degree of warmth when illness of any of the occupants of the house so demands.

Second. Particularly in a hot water system, the greater the amount of radiating surface there is in a room, the lower it will be necessary to maintain the temperature of the radiators to furnish adequate warmth to the surrounding air. In other words, the lower the temperature of the radiating surfaces by which the air is warmed, the more completely does the air retain its natural purity and vitality. The uniformity of the temperature of the freshly pure air is also thus best maintained, and drafts or overheating prevented.

Third. By having a boiler of ample size or capacity, a much slower combustion of the fuel is permissible. In consequence, the water surrounding the fire surfaces of the boiler will be cooler, and the greater will be the proportion of heat which the water will absorb. Fuel will thereby be saved, as, if the surfaces were hotter, the water could not as greedily and completely absorb

the heat, and a greater percentage of the heat would, therefore, be allowed to escape or to be wasted at the chimney.

Fourth. By having a boiler of ample capacity, the fire is so regulated that no more fuel is used than the amount needed to warm the air in the rooms to the degree of temperature desired. In these boilers a slow combustion of the fuel is maintained. It has been aptly said that in these boilers "the fire dwells and dwells." Aside from the advantage of securing a more thorough combustion of the fuel, a slow, deep fire also means far less care and attention,— twice a day in cold weather, or once on mild days.

Fifth. The mains and risers, or piping, should be of ample size, so that there cannot be any possibility of friction or choking (more commonly termed "pounding in the pipes"), which, in turn, means inefficiency or waste of fuel.

Sixth. To attempt to operate a boiler having a capacity of, say, 1500 square feet to carry 1800 square feet of direct radiation, is as destructive and wasteful, as, in a similar way, would be the effort to employ a ten-horse-power engine to carry the load of a twenty-horse-power engine, or to expect a 1000-pound horse to draw a three-ton load.

The difference in cost between a properly proportioned heating system as compared with one penuriously proportioned is too small to jeopardize the success of the investment. Dollars so withheld will, as surely as the continuation of time, have to be paid out over and over again in loss of comfort, waste of fuel, and greater care, aside from cost of probable repairs and alterations. Money judiciously expended is well invested.

To Properly Erect Coal, Coke and Wood Burning Sectional Steam and Water Boilers.* — Set up and bolt together squarely the pieces comprising the base, on a level brick or concrete foundation, which is at least a foot larger all round than the base.

Place all of the grates in position and connect them to the horizontal shaking bar underneath them. Connect this bar through the front of the base to the angle shaking lever, which is fastened to the front section by means of a bracket.

Place on top of the base, and close up against the base front the front section, which is marked No. 1. Wipe clean its nipple holes,

* These instructions are given by the American Radiator Co. for setting up the Ideal Boiler, but will apply to any sectional boiler.

also the connecting nipples; smear them with good lubricating oil; place them in the front section; add the second section marked No. 2, after having carefully wiped clean its nipple holes, pushing the section up until its front nipple holes register with the nipples already placed in the front section. Jar section No. 2 up close to the first one with a piece of timber. Place the four long connecting bolts in their holes, slipping on each, at the rear, one of the square wood washers usually supplied. Screw up *equally all around,* meanwhile striking the rear section, in the vicinity of the three connecting holes, with a block of wood and a good heavy hammer.

When the sections are within $\frac{1}{4}$ or $\frac{3}{16}$ of an inch of each other (*square all round*) then insert four wooden wedges, which are to go between each and every section before they are pulled up any farther, one on each side just above the lower connecting nipples and two on top. These two as far away from the upper connecting nipple as possible. Then screw a little more on the nuts until the wedges have been bitten by the two sections, and the sections have been drawn together from center to center of each section the following distances:

15″	Coal	Burning	Boiler	$6\frac{1}{4}$	from	Center	to	Center	of	Sections
18″	"	"	"	6″	"	"	"	"	"	"
21″	"	"	"	7″	"	"	"	"	"	"
24″	"	"	"	$7\frac{1}{4}$″	"	"	"	"	"	"
30″	"	"	"	$7\frac{1}{4}$″	"	"	"	"	"	"
36″	"	"	"	$8\frac{1}{4}$″	"	"	"	"	"	"
No. 1	Coke	"	"	4″	"	"	"	"	"	"
" 2	"	"	"	$5\frac{1}{2}$″	"	"	"	"	"	"
" 3	"	"	"	6″	"	"	"	"	"	"
" 4	"	"	"	$7\frac{1}{4}$″	"	"	"	"	"	"
" 5	"	"	"	$8\frac{1}{4}$″	"	"	"	"	"	"

Then remove the screw rods, add the next section, precisely as before, and repeat the operation just described, sawing off each time, where they have been marked, a portion of the square wood washers.

If impossible to begin to erect at the front section of boiler, start with the back section, as above described.

After boiler has been assembled complete, be sure to cement all joints (which are all points of contact) between sections, breaking off the wood wedges, allowing their points to remain

undisturbed between the sections, applying cement over them. Cement all joints in base and between base and foundation, remembering that all air for combustion should enter only through the draft doors.

Smoke pipe and all connections between boiler and flue should be air-tight (a leak in the smoke pipe or connections is like a leak in a suction pump).

Do not bush the flow outlets in steam dome. Connect all of them to the flow pipe system, using size of pipe called for by outlets.

Do not expect the boiler to do good work until the system has been thoroughly cleared of oil.

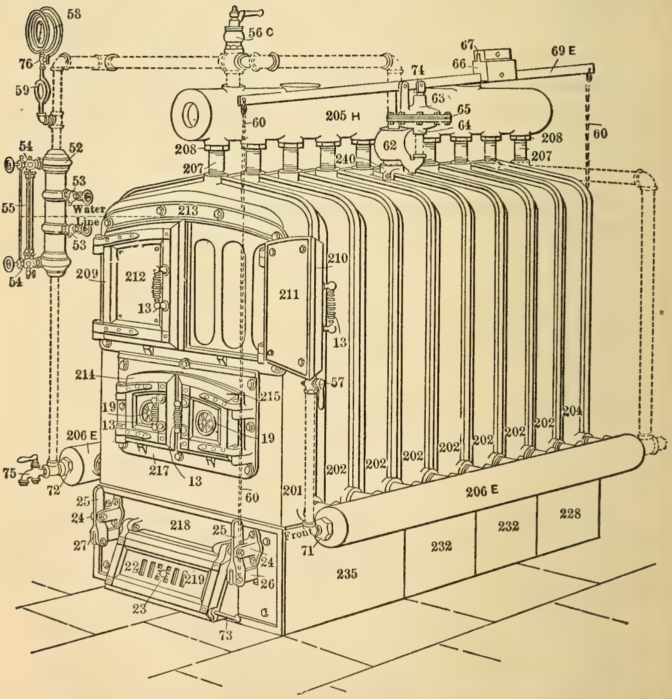


Fig. 53. Parts of Sectional Steam and Hot Water Boilers.

A good damper (accessible and easily handled) in smoke pipe near chimney, provided with means for clamping in order that it may remain where desired, is usually very necessary for draft regulation and fuel saving.

No boiler will operate successfully on a weak draft, nor will it give satisfaction on a strong draft *if the flue area is too small.* (Do not mistake velocity for volume. A test by burning paper in a flue proves nothing.)

Each pound of coal requires for its complete combustion about three hundred cubic feet of air.

To draw this amount of air through the grates, ashes and fuel bed, over various heating surfaces and through flues, the proper area and height of chimney are essential.

Names of Parts of Steam and Water Boiler as Shown on Figs. 53 and 54.

7. Nipples.
8. Lock nuts.
13. Flue door and fire door handle.
19. Fire door dampers.
22. Ash front door slide.
23. Ash front door slide knob.
24. Action bracket.
25. Action bracket lever.
26. Short action bar.
27. Long action bar.
45. Grate spindle.
52. Water column.
53. Gauge cock.
54. Water gauge cock.
55. Water gauge glass.
56. Pop valve.
57. Steam cock.
58. Steam gauge.
59. Steam gauge siphon.
60. Jack chain.
62. Bottle.
63. Diaphragm case (top).
64. Diaphragm case (bottom).
65. Diaphragm case (rubber).
66. Diaphragm case (weight).
70. Cotter pin.
71. Bushing.
73. Ash front door lift.
74. Diaphragm spindle.
75. Hose bib.
76. Steam gauge cock.
201. Front section.
202. Leg section.
203. Fire back section.
204. Extreme back section.
206. Return drum.
207. Nipples.
208. Lock nuts.
209. Left-hand flue door.
210. Right-hand flue door.
211. Flue door lining.
212. Flue door name plate.
213. Flue door frames.
214. Left-hand fire door.
215. Right-hand fire door.
217. Fire door frames.
218. Ash front.
219. Ash front door.

PARTS SHOWN ONLY ON FIG. 54.

220. Back bonnet.
221. Back bonnet door.
222. Back bonnet door frames.
224. Ash pit back end.

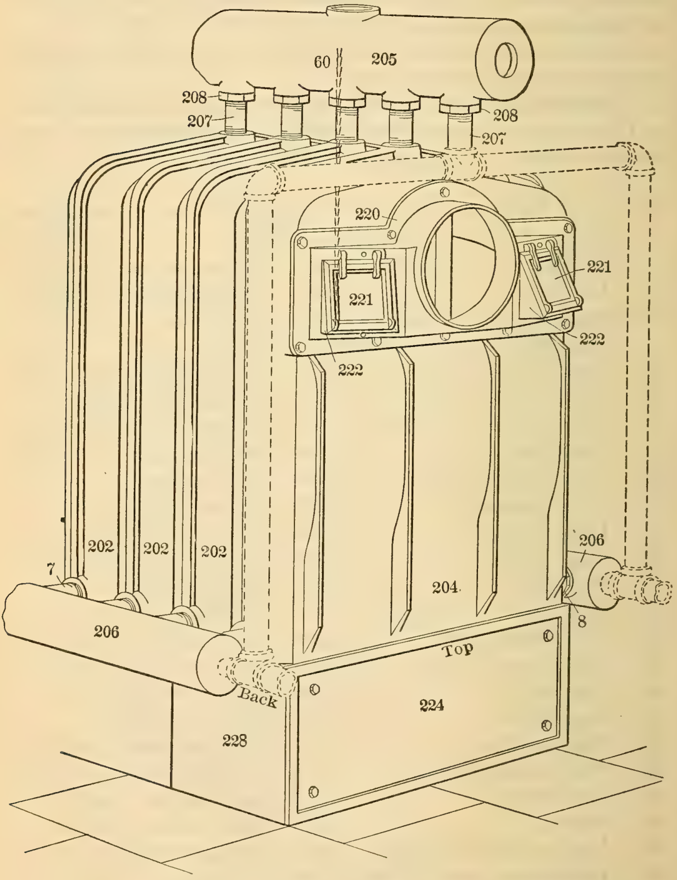


Fig. 54. Parts of Sectional Steam and Hot Water Boiler (Rear View).

Blowing Off a Steam Boiler.

A steam boiler should be blown off within one week after it is in operation to remove the unavoidable accumulation of oil, grease, etc., that have a tendency to cause a boiler to foam, preventing the generation of steam and causing an unsteady water line. This can only be done when the boiler is under pressure. If one blowing off does not result in a steady water line and clean gauge, the operation must be repeated a second or, if necessary, a third and fourth time.

1. Close all radiator valves, or, if the mains are valved, close both flow and return valves tightly, and also close the cock below the diaphragm regulator on boiler.
2. With a wood fire and boiler filled to center of water glass, get up a pressure of not less than 10 to 12 pounds by the steam gauge.
3. Open the blow-off cock, being careful that sufficient fire is carried to maintain a pressure until the last gallon of water is blown out.
4. Draw any remaining fire and open all fire and flue doors wide.
5. Allow the boiler to cool down, which will probably take from one-half to one hour, then close the blow-off cock and slowly fill boiler to water line.
6. Open all valves on flow and return lines, the diaphragm cock, and also the radiator valves.
7. Rebuild fire.
8. Repeat the operation until there is a steady water line and a clean gauge glass.

Horse-Power of Boilers.

Horse-power is a very elastic phrase as applied to boilers, and quite empirical. It may serve as a descriptive or a comparative term, but not as expressing any comprehensible power.

The unit of power for boilers, adapted by the committee of judges of the Centennial Exhibition, and now generally used, is as follows:

One horse-power equals 30 pounds of water evaporated into dry steam per hour, from feed water at 100° F., and under a pressure of 70 pounds per square inch above atmosphere.

When boilers are rated according to their heating surface, 15 square feet is generally taken as the unit for one horse-power,

and each horse-power of the boiler will supply from 240 to 360 feet of one-inch steam pipe, or from 80 to 120 square feet of radiating surface.

The grate area required for various boilers may be computed from the horse-power of the boiler as follows:

Cylinder boiler,	multiply	the	horse-power	by	.60
Flue boiler,	"	"	"	"	.45
Return tubular boiler,	"	"	"	"	.50
Water tube,	"	"	"	"	.30
Vertical boiler,	"	"	"	"	.65

Cast iron boilers, or heaters, are rated by the manufacturers by the amount of direct radiation they will supply, and are usually rated high, so when installing a boiler of this type select one with a rating of from 25 to 40 per cent higher than the radiation you have to supply.

One square foot of grate surface will consume 10 to 12 pounds of hard coal, or 18 to 20 pounds of soft coal, per hour, with natural draft. When forced drafts are used, these amounts can be doubled.

Good boilers will evaporate from 8 to 10 pounds of water per pound of coal.

Steam engines will consume from 15 to 60 pounds of water, and from $1\frac{1}{2}$ to 7 pounds of coal per hour, for one indicated horse-power.

Two and one-fourth pounds of dry wood are equal to 1 pound of average soft coal.

To Clean a Water Gauge Glass without Removing it from Boiler. — 1. Draw a cup full of hot water from the boiler, into which put at least a tablespoonful of raw muriatic or other acid.

2. Close both water gauge valves.

3. Open top water gauge valve and also pet cock at bottom, and blow water out of the glass. Then immediately close the top valve and submerge the end of the pet cock in the cup of acid solution. A vacuum is at once created in the gauge glass which causes the solution in the cup to rush into the glass.

4. Keep the pet cock immersed and operate the top valve slightly opening and closing, alternately expelling and drawing, in the solution until all grease, oil or other matter adhering to the

inside of the glass is cut out. Then close pet cock and open both water gauge valves.

It is necessary to have at least one pound of steam pressure before commencing the operation, which will take only about ten minutes.

Glasses can be cleaned in this manner, and there is no risk of breakage as when the glass is taken out.

To Find the Strength of a Boiler. — To find the safe pressure a cylindrical boiler will bear in pounds per square inch: Divide the thickness of the plate in inches by the diameter in inches, and multiply the quotient by:

5,000 for a copper boiler with single riveted shell.
6,400 for a copper boiler with double riveted shell.
7,600 for a wrought iron boiler with single riveted shell.
9,000 for a wrought iron boiler with double riveted shell.
10,000 for a steel boiler with single riveted shell.
12,000 for a steel boiler with double riveted shell.

Care of Boilers. — The following rules have been compiled by Henry Diston & Sons from those issued by the various Boiler Insurance Companies of this country and Europe. They are applicable to all boilers except as otherwise noted.

Attention Necessary to Secure Safety.

1. Safety Valves. — Great care should be exercised to see that these valves are ample in size and in working order. Overloading or neglect frequently lead to the most disastrous results. Safety valves should be tried at least once every day to see that they will act freely.

2. Pressure Gauge. — The steam gauge should stand at zero when the pressure is off, and it should show same pressure as the safety valve when that is blowing off. If not, then one is wrong, and the gauge should be tested by one known to be correct.

3. Water Level. — The first duty of an engineer before starting, or at the beginning of his watch, is to see that the water is at the proper height. Do not rely on glass gauges, floats or water alarms, but try the gauge cocks. If they do not agree with water gauge, learn the cause and correct it.

4. Gauge Cocks and Water Gauges must be kept clean.

Water gauge should be blown out frequently, and the glasses and passages to gauges kept clean. The Manchester, England, Boiler Association attributes more accidents to inattention to water gauges than to all other causes put together.

5. Feed Pump or Injector. — These should be kept in perfect order, and be of ample size. No make of pump can be expected to be continuously reliable without regular and careful attention. It is always safe to have two means of feeding a boiler. Check valves and self-acting feed valves should be frequently examined and cleaned. Satisfy yourself frequently that the valve is acting when the feed pump is at work.

6. Low Water. — In case of low water, immediately cover the fire with ashes (wet if possible), or any earth that may be at hand. If nothing else is handy, use fresh coal or sawdust. Draw fire as soon as it can be done without increasing the heat. Neither turn on the feed, start or stop engine, or lift safety valve until fires are out, and the boiler cooled down.

7. Blisters and Cracks. — These are liable to occur in the best plate iron. When the first indication appears, there must be no delay in having it carefully examined and properly cared for.

Fusible Plugs, when used, must be examined when the boiler is cleaned, and carefully scraped on both the water and fire sides, or they are liable not to act.

Attention Necessary to Secure Economy.

8. Cleaning. — All heating surfaces must be kept clean, outside and in, or there will be a serious waste of fuel. The frequency of cleaning will depend on the nature of fuel and water. As a rule, never allow over $\frac{1}{16}$ inch scale or soot to collect on surfaces between cleanings. Hand holes should be frequently removed and surfaces examined, particularly in case of new boiler, until proper intervals have been established by experience.

9. Hot Feed Water. — Cold water should never be fed into any boiler when it can be avoided, but when necessary it should be caused to mix with the heated water before coming in contact with any portion of the boiler.

10. Foaming. — When foaming occurs in a boiler, checking the outflow of steam will usually stop it. If caused by dirty

waters, blowing down and pumping up will generally cure it. In case of violent foaming, check the draft and fires.

11. Air Leaks. — Be sure that all openings for admission of air to boiler or flues except through the fire are carefully stopped. This is frequently an unsuspected cause of serious waste.

12. Blowing Off. — If the feed water is muddy or salt, blow off a portion frequently, according to condition of water. Empty the boiler every week or two, and fill up afresh. When surface blowcocks are used, they should be often opened for a few minutes at a time. Make sure no water is escaping from the blow-off cock when it is supposed to be closed. Blow-off cocks and check valves should be examined every time the boiler is cleaned.

Attention Necessary to Secure Durability.

13. Leaks. — When leaks are discovered, they should be repaired as soon as possible.

14. Blowing Off. — Never empty the boiler while brick-work is hot.

15. Filling Up. — Never pump cold water into a hot boiler. Many times leaks, and in shell boilers, serious weakness, and sometimes explosions, are the result of such an action.

16. Dampness. — Take care that no water comes in contact with the exterior of the boiler from any cause, as it tends to corrode and weaken the boiler. Beware of all dampness in seating or coverings.

17. Galvanic Action. — Examine frequently parts in contact with copper or brass where water is present, for signs of corrosion. If water is salt or acid, some metallic zinc placed in the boiler will usually prevent corrosion, but it will need attention and renewal from time to time.

18. Rapid Firing. — In boilers with thick plates or seams exposed to the fire, steam should be raised slowly, and rapid or intense firing avoided. With thin water tubes, however, and adequate water circulation, no damage can come from this cause.

19. Standing Unused. — If a boiler is not required for some time, empty and dry it thoroughly. If this is impracticable, fill it quite full of water and put in a quantity of common washing soda. External parts exposed to dampness should receive a coating of linseed oil.

20. General Cleanliness. — All things about the boiler room should be kept clean and in good order. Negligence tends to waste and decay.

Why Water Leaves a Boiler.* — There are only three reasons why the water in a boiler should get up into the mains. In making the statement I have not taken into consideration possible accidents such as leaks, burst fittings or pipes from settling of buildings or causes of that nature; carelessness of servants or others in drawing water from the system for domestic purposes; half closed radiator valves causing water to be forced into the radiator, or drawn in from the vacuum caused by the condensation of steam, etc. I have not taken into consideration the fact that supply valves might be left open or might leak and flood the system. The statement is based on the supposition that the apparatus has been well put up, given ordinarily intelligent attention and care, and that the conditions are favorable to the possibility of its working.

Water strongly saturated with an alkaline matter, or carrying in solution some mineral matter that would cause it to be light or foamy, is a very common condition in certain localities. Faulty boiler construction resulting in inferior interior water circulation is the most serious and as well the hardest condition to overcome; in fact, a remedy is not at hand. Yet it may be well to name some of the narcotics commonly used: Bleeders, drips, rain spouts, increased water column capacity, increased boiler capacity, attaching bottom of water column to rear of boiler or to return some distance from boiler, and similar methods. While some of the above correctives sometimes provoke a settlement, the case is chronic and can never be associated with the convalescent. On account of inferior circulation the water is unable to return to the bottom of the boiler or waterways.

Water Carried by Steam. — The surface of the water may not be of sufficient area for the proper liberation of the steam from the water, the latter thus being carried up into the mains. The most probable reason is that there is no direct waterway by which the water can be returned to the bottom of the boiler, and the waterways being so small that the little particles of water generated into steam fill the waterways, and in their

* Abstract of a paper read at the recent convention of the representatives of the Herendeen Mfg. Company, manufacturers of heating boilers, Geneva, N. Y., by Edward S. Dean of Illinois.

upward tendencies not only carry the water with them, but prevent its return, finally carrying the water into the mains. There it is either returned to the boiler through a bleeder, rain-spout, drip, or *via* the main and back through the regular return to replenish the boiler.

Particularly are boilers with single water legs at either side of the fire pot bothered thus, and the smaller and longer these waterways the more would the boiler be subject to trouble of this nature. This trouble is not always apparent in the mains, but is sometimes shown by the unsteady water line of the boiler. The cause is the same, the remedy similar. The Furman boiler is blessed with a large return waterway at either side of either fire pot section, and this waterway does not come in contact with the direct intense action of the fire from the fire pot. If the trouble occurs in a plant with a Furman you can look at once for the trouble elsewhere, and it therefore must be in one of the other two causes.

A very common method is to connect all the outlets of the boiler to a large common header or pipe, which in turn is used as a steam dome and out of which the main supply pipes for the job are taken. This large pipe header or dome has attached to it from one end or the bottom a drip, bleeder, rain spout, or something of this nature, which is attached to the bottom or return of the boiler, and through this pipe or drip the water, which has been carried out of the boiler, is carried back into the boiler, thus completing the circulation of the boiler, as we might say.

Size of Piping for Work in Hand. — The cause of the delivery of the steam to and through the mains is unequal pressure — that is, steam is forced out of the boiler and into the main because the pressure in the main is less than it is in the boiler, and the pressure at the far end of the main is the least, there being a difference of a fraction of an ounce to upward of a pound in the ordinary job when working. The difference will average nearly $\frac{1}{8}$ pound pressure, providing, of course, that the main is of the proper size.

We will assume that a 2-inch main will deliver steam to, or carry, only 350 square feet of radiation and maintain in the far end a minimum pressure. Now suppose that we add 100 feet of radiation to the same 2-inch main, and we find that to deliver the steam we will be compelled to increase the boiler pressure

in order to force the steam out of the boiler through the main and to the radiators. Supposing this pressure needed is 5 pounds, we find that we can deliver the steam, but we cannot retain a pressure in the far end of the main to equal the increased boiler pressure, and we also find that the pressure in the far end of the main is about the same as with the 350 feet. This increased boiler pressure pushes down on the water just as hard as it pushes up on the steam, and in the absence of a pressure at the far end of the main to equal the boiler pressure, the water is driven down in the boiler and up the return pipe until the water backs up into the main to such a point as will equalize (nearly) the pressure. The result: loss of water from the boiler, water hammering, water in the radiators, on the carpets, and the owner doesn't pay. Total ignorance of the cause is the reason why a great many fitters always place check valves in their returns; this is not a remedy, but merely a relief in part.

It is not always a small main pipe, but sometimes trouble is due to a gasket having too small a hole, or possibly a valve partially closed, or a valve with too small an opening through it, or some other obstruction. The trouble of water in the main is more apt to appear where the mains are very close to the water line than where the main is several feet above the water line of the boiler, because it requires less pressure to force the water up into the main pipe. The cause is ignorance; the remedy, increase capacity of main; the preventative, use main of sufficient capacity; the relief, place a check valve in the return and warm up a portion of the radiation at a time.

MISCELLANEOUS INFORMATION.

Chimneys, their Construction and Importance. — A factor of prime importance in any heating system, which is often overlooked by the heating contractor, architect, or owner, is the chimney flue.

A chimney flue to effect the best results should be round. Next in order of efficiency comes the square flue, while the least effective is one of oblong form. The round flue presents an amount of friction surface to the smoke and escaping gases equal to about 3½ times its diameter; the square flue presents four times its diameter as friction surface; while the oblong flue's friction surface increases beyond that of the square flue

in direct proportion to its extent of elongation. As an illustration: In an 8-inch round flue, the friction surface is 25.13 inches and contains 50.265 square inches of area. In an 8-inch square flue, the friction surface is 32 inches and contains 64 square inches of area; while in an oblong flue 4 × 16 inches, the friction surface is 40 inches and the area 64 square inches.

If the square form of flue is desired, the side of the square should be at least equal to the diameter of the boiler smoke pipe, as the corners of the square flue are of practically no value for the smoke passage, and in very large flues even become a detriment, in the way of eddying currents which upset the true course of smoke and escaping gases. In other words, the 64 square inches in the 8-inch square flue are of no greater value, if as great, for the smoke passage, than the 50.265 square inches of the 8-inch round flue.

In an oblong flue, the depth should never be less than 6 to 8 inches, even for the smallest flues; and the length not to exceed $1\frac{3}{4}$ times the depth. If an oblong flue is unavoidable, better results will be obtained if the smoke pipe can enter the flue on the narrow side, as this will allow the smoke and escaping gases more room in which to change their course from the horizontal smoke pipe to the vertical flue. A flue of less than 6 inches depth will not allow freedom for this change of direction, which directly accounts for the unsuccessful operation of boilers using shallow flues, and the blame is often put on the entire system. Be sure that the flue is of the proper size and shape, and has a good draft before attaching the boiler to it; for many heating systems, first class in other respects, fail to give satisfaction merely on account of poor chimney drafts.

A newly built chimney will not draw perfectly until it is thoroughly dried out, which will take a week or two.

In looking over the chimney and connecting it to the boiler, it is well —

First. To see there are no openings into the boiler flue, either above or below the boiler smoke pipe; special care being exercised at the base of the flue, that the boiler flue does not connect with any other flue in the chimney through the soot pocket or base of the flue.

Second. That the division walls of the chimney, if it contains more than one flue, are carried to the top of the chimney, so that each flue is independent of the others its entire length.

Third. That the area of the chimney flue is maintained full size its entire length, and is free from obstructions, such as loose brick, mortar, etc., that might become lodged in it.

Fourth. That the chimney extends above the highest point of the roof, or other surrounding elevation. This is quite important, and failure to observe this rule may be looked to as a cause for poor draft.

Fifth. That the flue is at least 6 or 7 inches in depth, and never less in area than the size of the smoke pipe given by the boiler manufacturer.

Sixth. That the boiler sets as near the chimney as possible, thus shortening the length of the horizontal smoke pipe.

Seventh. That the smoke pipe does not project into the chimney too far, and thus lessen the area of the flue at this important point, where the smoke leaves the pipe and enters the flue.

Chimney Flues. — The selection of chimney flues for heating boilers must depend upon the judgment of the heating engineer. No tabular statements can be guaranteed, but it is believed that the table herewith, of Professor R. C. Carpenter, is as reliable as any.

Direct Radiation.*		Height of Chimney Flue.					
Steam in Square Feet.	Water in Square Feet.	20 ft.	30 ft.	40 ft.	50 ft.	60 ft.	80 ft.
250	375	7.4	7	6.7	6.4	6.2	6
500	750	9.6	9.2	8.8	8.2	8	6.6
750	1150	11.3	10.8	10.2	9.6	9.3	8.8
1000	1500	12.8	12	11.4	10.8	10.5	10
1500	2250	15.2	14.4	13.4	12.8	12.4	11.5
2000	3000	17.2	16.3	15.2	14.5	14	13.2
3000	4500	20.6	18.5	18.2	17.2	16.6	15.8
4000	6000	23.6	22.2	20.8	19.6	19	17.8
5000	7500	26	24.6	23	21.6	21	19.4
6000	9000	28.4	26.8	25	23.4	22.8	21.2
7000	10500	30.4	28.8	27	25.5	24.4	23
8000	12000	32.4	30.6	28.6	26.8	26	24.2
9000	13500	34	32.4	30.4	28.4	27.4	25.6
10000	15000	37	34	32	30	28.6	27

* When a considerable amount of indirect radiation is to be used, increased boiler capacity is necessary, and in many cases such demands require a larger chimney flue for same number of square feet of radiation used.

It is necessary that area and height, thickness of walls, general structure, and the position of the top outlet with reference to the building and other buildings near by, should be carefully noted and observed in the selecting or building a flue.

The figures given under the varying heights of chimneys are diameter measurements in inches, or, the side of a square — the theory being that the spiral ascending column of smoke and gases will make a twelve by twelve inch flue no more extensive in practical working area than a twelve-inch round flue. Rectangular shapes may be used if the area is equal and the difference in width and length are not extreme.

A Less Specific Rule for Chimney Flues. — Herewith is a table of chimney flue sizes which is commonly used with good results. It does not take into consideration varying heights of stacks, but is said to be reliable in average conditions.

Direct Radiation.*		Size of Flue.	
Steam in Square Feet.	Water in Square Feet.	Round.	Square.
250	400	8	8×8
300	500	8	8×8
400	700	8	8×8
500	850	10	8×12
600	1000	10	8×12
700	1200	10	8×12
800	1350	12	12×12
900	1500	12	12×12
1000	1700	12	12×12
1200	2100	12	12×12
1400	2400	14	12×16
1600	2700	14	12×16
1800	3000	14	12×16
2000	3400	14	12×16
2200	3700	16	16×16
3000	5100	16	16×16
3500	5900	18	16×20
5000	8500	18	16×20

* When a considerable amount of indirect radiation is to be used, increased boiler capacity is necessary, and in many cases such demands require a larger chimney flue for same number of square feet of radiation used.

SIZES OF CHIMNEYS WITH APPROPRIATE HORSE-POWER OF BOILERS.

Diameter in Inches.	Height of Chimneys and Commercial Horse-Power.											Side of Square, Inches.	Effective Area, Sq. Ft.	Actual Area, Sq. Ft.
	50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.	110 ft.	125 ft.	150 ft.	175 ft.	200 ft.			
18	23	25	27	......	......	......	......	......	......	......	......	16	0.97	1.77
21	35	38	41	......	......	......	......	......	......	......	......	19	1.47	2.41
24	49	54	58	62	......	......	......	......	......	......	......	22	2.08	3.14
27	65	72	78	83	......	......	......	......	......	......	......	24	2.78	3.98
30	84	92	100	107	113	......	......	......	......	......	......	27	3.58	4.91
33	......	115	125	133	141	......	......	......	......	......	......	30	4.48	5.94
36	......	141	152	163	173	182	......	......	......	......	......	32	5.47	7.07
39	......	......	183	196	208	219	......	......	......	......	......	35	6.57	8.30
42	......	......	216	231	245	258	271	......	......	......	......	38	7.76	9.62
48	......	......	......	311	330	348	365	389	......	......	......	43	10.44	12.57
54	......	......	......	363	427	449	472	503	551	......	......	48	13.51	15.90
60	......	......	......	505	536	565	593	632	692	748	......	54	16.98	19.64
66	......	......	......	......	658	694	728	776	849	918	981	59	20.83	23.76
72	......	......	......	......	792	835	876	934	1023	1105	1181	64	25.08	28.27
78	......	......	......	......	......	995	1038	1107	1212	1310	1400	70	29.73	33.18
84	......	......	......	......	......	1163	1214	1294	1418	1531	1637	75	34.76	38.48
90	......	......	......	......	......	1344	1415	1496	1639	1770	1893	80	40.19	44.18
96	......	......	......	......	......	1537	1616	1720	1876	2027	2167	86	46.01	50.27
102	......	......	......	......	......	......	......	1946	2133	2303	2462	90	52.23	56.75
108	......	......	......	......	......	......	......	2192	2402	2594	2773	96	58.83	63.62
114	......	......	......	......	......	......	......	2459	2687	2903	3003	101	65.83	70.88
120	......	......	......	......	......	......	......	......	2990	3230	3452	106	73.22	78.54
126	......	......	......	......	......	......	......	......	3308	3573	3820	112	81.00	86.59
132	......	......	......	......	......	......	......	......	3642	3935	4205	117	89.19	95.03
138	......	......	......	......	......	......	......	......	3991	4311	4608	122	97.75	103.86
144	......	......	......	......	......	......	......	......	4357	4707	5031	127	106.72	113.10

Injectors, Piping and Operating.

Steam Pipe. — The steam supply to an Injector should always be taken from the dome or highest point of the boiler so that the steam will be as dry as possible. The pipe should be as large as or larger than the supply connection to the Injector, and should be an independent pipe so there will be no cut off to the supply.

Feed Pipe.—The feed or suction pipe should be the full size of the supply opening to the Injector, and must be perfectly air-tight.

Delivery Pipe. — The delivery pipe must be of full size, and the check valve have a full opening the size of the pipe. If the check valve is too small, or by the accumulation of sediment the opening is partly closed, it will prevent the water from being delivered into the boiler as fast as the Injector discharges it. The result is, a pressure is caused greater than the boiler pressure, and will increase until the Injector cannot force any more and the feed is broken.

Failure to Work. — Generally the cause of Injectors failing to work is a leak in the suction pipe. This pipe must be absolutely tight or the Injector will not work.

If steam and hot water come out of the overflow together, the trouble may be due to too high a steam pressure for the lift; too hot water supply; or suction pipe clogged.

If the Injector lifts the water, but does not force it into the boiler, the trouble may be a leak in the suction pipe; wet steam; not sufficient steam pressure; steam supply pipe not direct from boiler; delivery pipe clogged; or the check valve not lifting high enough or not at all.

If the Injector refuses to lift the water, the trouble may be due to too low a steam pressure for the lift; suction pipe clogged; water supply too hot; wet steam; overflow valve stuck or overflow pipe too small; or a leak in the suction pipe.

Range of Injectors. — The lowest steam pressure at which an Injector will start, and the highest at which it will work, is termed the "range" of the Injector, and this varies with the vertical lift and the temperature of the feed water.

Different manufacturers therefore vary as to the starting-point in their Injectors, aiming to cover the range they deem the most desirable. Nearly all have adopted about 25 pounds on a 2-foot lift as the lowest starting-point.

The range of Injectors is approximately as follows:

With Supply Water at 60° F.

On a 2-ft. lift	will start at 15 lbs. steam.
	will work to 155 lbs. steam.
On an 8-ft. lift	will start at 25 lbs. steam.
	will work to 135 lbs. steam.
On a 14-ft. lift	will start at 40 lbs. steam.
	will work to 110 lbs. steam.
On a 20-ft. lift	will start at 55 lbs. steam.
	will work to 85 lbs. steam.

With Feed Water at 75° F.

On a 2-ft. lift	will start at 15 lbs. steam.
	will work to 145 lbs. steam.
On an 8-ft. lift	will start at 25 lbs. steam.
	will work to 125 lbs. steam.
On a 15-ft. lift	will start at 45 lbs. steam.
	will work to 85 lbs. steam.
On a 20-ft. lift	will start at 55 lbs. steam.
	will work to 75 lbs. steam.

With Feed Water at 100° F.

On a 2-ft. lift	will start at 20 lbs. steam.
	will work to 120 lbs. steam.
On a 10-ft. lift	will start at 35 lbs. steam.
	will work to 90 lbs. steam.
On a 15-ft. lift	will start at 45 lbs. steam.
	will work to 70 lbs. steam.

Ejectors.

Ejectors work on the same principle as Injectors, except that they have no pressure to counteract or overcome, and can therefore lift the water to a considerable height, and are often used to elevate water from pits, mines, quarries, etc., or to fill tanks above the water level.

Connecting and Operating Ejectors. — Connect the Ejector in any position to suit the convenience of piping. Where water is to be forced to a greater height than 40 feet above the Ejector, place the Ejector not to exceed 10 feet above the water level. Where the Ejector has to be placed at a greater distance

above the water level, and the water is to be forced to a greater height above the Ejector, use one size larger pipe on the delivery.

The following table gives the heights to which Ejectors will lift under different pressures of steam.

With 25 Pounds Steam —

Lifts	10	feet and	elevates above itself	11	feet.
"	5	"	" "	13	"

With 40 Pounds Steam —

Lifts	22	feet and	elevates above itself	20	feet.
"	15	"	" "	27	"
"	5	"	" "	29	"

With 60 Pounds Steam —

Lifts	20	feet and	elevates above itself	36	feet.
"	15	"	" "	43	"
"	10	"	" "	48	"
"	5	"	" "	50	"

With 80 Pounds Steam —

Lifts	18	feet and	elevates above itself	55	feet.
"	15	"	" "	59	"
"	10	"	" "	61	"
"	5	"	" "	66	"

With 100 Pounds Steam —

Lifts	17	feet and	elevates above itself	61	feet.
"	15	"	" "	63	"
"	10	"	" "	66	"
"	5	"	" "	73	"

With 125 Pounds Steam —

Lifts	15	feet and	elevates above itself	76	feet.
"	10	"	" "	83	"
"	5	"	" "	90	"

Cellar Drainers.

Cellar Drainers work on the same principle as Injectors and Ejectors, except that water, under pressure, is used as their source of power. They are made to operate automatically as follows:

As soon as the water to be removed accumulates, a float ball rises and opens the valve admitting the water under pressure

through the supply pipe, which causes a vacuum or suction, and draws the accumulated water forcing it into and through the discharge pipe, continuing until the water is lowered and the float ball falls and shuts off the water supply, and ceases pumping, thus starting and stopping automatically as the water accumulates to be removed. The Cellar Drainer can also be operated with steam in the place of water, and then takes the form of the Ejector.

INSTALLING THE CELLAR DRAINER. — A suitable depression of 18 inches or more below the level of the place to be drained having been made, if in soil or sand and intended for permanent use, should be lined with brick, cement or wood, to prevent caving in (or with a small size drainer an oil barrel sawed in two, with a few auger holes in the sides, will answer the purpose), and the Cellar Drainer placed therein. Connections are then made to a supply pipe and a discharge pipe. The supply pipe being connected to the service pipe or tank, or to any pipe conducting water under pressure, is then connected to the valve. The discharge pipe is connected to the Cellar Drainer and carried to the point of discharge. Should this be in a sewer, tide or river water, a check valve should be placed in the discharge pipe to prevent outside water from backing up to the Cellar Drainer.

The valve will regulate the supply of water under pressure, shutting off the supply automatically when not in operation, but opening as soon as the water to be removed accumulates. The cesspool should be covered to keep out dirt and rubbish.

Cellar Drainers will lift water up to about 12 feet, and for every foot of lift should have 5 pounds pressure on the water supply. Thus Cellar Drainers will lift water as follows:

To raise water

1 ft.	high,	it	requires	from	4	to	5	lbs.	pressure,
2 ft.	"	"	"	"	8	"	10	"	"
3 ft.	"	"	"	"	12	"	15	"	"
4 ft.	"	"	"	"	16	"	20	"	"
5 ft.	"	"	"	"	20	"	25	"	"

and so on in proportion up to 12 feet in height.

When connecting up a Drainer, be sure and blow out the supply pipes, so that no dirt or scales can lodge in front of the jet, which would prevent the Drainer from working properly;

also have the discharge pipe laid on a descent, after raising the pipe to the full height of the lift, so as not to have the body of water which is lying in the discharge pipe forced against the Drainer, but have it so that the water which is raised to the proper height can run off itself from that point; or if the discharge can be carried downward after passing the highest point, the discharge will then form a siphon and assist the Drainer with its work.

Hydraulic Ram.

The Hydraulic Ram is a mechanical device or engine, which operates automatically, for raising a small quantity of water to a desired height, by using the force or power obtained by the weight or fall of a large body of water from a less height than that to which the water is elevated. Thus by means of the Hydraulic Ram water can be raised to a much greater height than the source of supply.

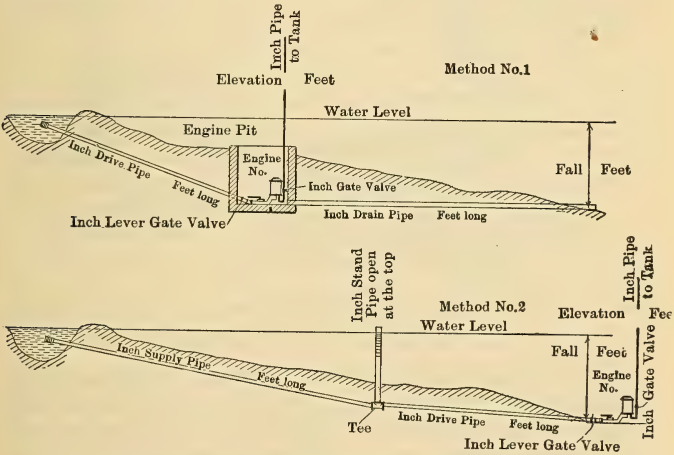


Fig. 55. Method of Securing Fall for Hydraulic Rams.

The height to which water can be raised depends on the amount of fall from the source of supply to the Ram. The raising power is given by the elastic reaction of a confined volume of air, which is compressed by the falling water.

Fig. 55 shows two different methods of securing fall for water to operate Hydraulic Rams.

Description and Operation of the Hydraulic Ram. — As Hydraulic Rams all operate on the same principle, the following description of the Rife Hydraulic Ram is given.

* The Hydraulic Ram has been used in a small way ever since its invention by Joseph Michael de Montgolfier, in 1796, to whom credit is given for having first perfected the automatic machine.

John Whitehurst, of Derby, England, is said, however, to have understood the principle as early as 1775, but his machine required an attendant who opened and closed the waste valve by hand.

Hydraulic Rams are in quite common use, but they are practically all of small size, designed to raise but small quantities of water, and that to small heights.†

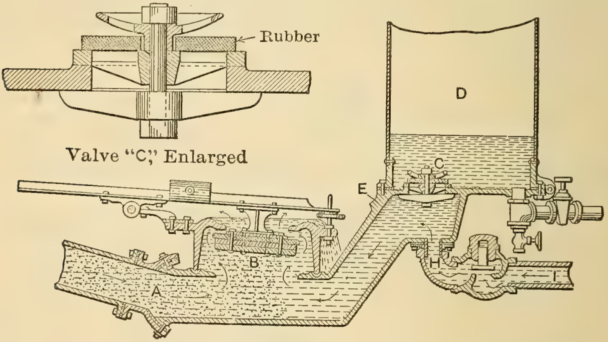


Fig. 56. Section of Rife Hydraulic Ram for Pumping Pure Water, Using Impure Water for Power.

The Rife Hydraulic Engine Co., New York City, however, is manufacturing an improved Ram, which is of sufficient size and capacity to deserve the name of engine. A section of the double-acting or double-supply type, to be described later, is shown in Fig. 56.

* Engineering News.

† The Columbia Engineering Works, Portland, Oregon, now manufacture a 48-inch Ram, which they claim with a drive of 19,000 cubic feet of water per minute from a height of 50 feet, will raise 6000 cubic feet of water per minute to a height of 200 feet, and at Sunnyside, Wash., a battery of 11 rams lift water to a height of 147 feet, the supply having a fall of 39 feet. (*Author.*)

Considering it first without any regard to the double-supply feature, suppose the opening at H to be closed. The valve at B being open, the water from the source of supply at more or less elevation above the machine flows down the drive pipe A and escapes through the opening at B until the pressure due to the increasing velocity of the water is sufficient to close the valve B. At the moment when the flow through this valve ceases, the inertia of the moving column of water produces the so-called ramming stroke, which opens the valve at C, and compresses the air in the air chamber D until the pressure of the air plus the pressure due to the head of the water in the main is sufficient to overcome the inertia of the moving column of water in the drive pipe. This motion may be likened to the oscillations in a U-tube. At this instant the column of water in the drive pipe has come to a rest, and the air pressure being greater than the static head alone, the direction of the motion of the moving column is reversed and the valve C is closed. The water in the drive pipe is then moving backward, and with the closing of C a tendency to a vacuum is produced at the base of the drive pipe; this negative pressure causes the valve B to open again, completing the circle of operations. At the moment of negative pressure the little shifting valve E admits a small quantity of air, and at the following stroke this passes into the air chamber, which would otherwise gradually fill with water, the air being gradually taken up by water.

In many machines the mistake is made of making the waste valve B sufficiently heavy to overcome the static head of water in the drive pipe. In fact, most writers on this subject, including the *Encyclopedia Britannica*, state that the weight of the waste valve B must be greater than the pressure of the statical head of water on its under side so that it may open when the column of water comes to rest. In the machine which we are describing, this would be practically impossible on account of the large area of the opening at B.

In this machine the valve B is made as light as is consistent with the necessary strength; the negative pressure at the end of the stroke is relied upon to open the valve. With the largest size of these machines this valve is eighteen inches in diameter, and with a head of eight feet, which is a common head for use with hydraulic rams, the static pressure on the under side of this valve is eight hundred and eighty-three pounds; it can be seen

that the great shock of a valve of this weight would rapidly destroy the valve and its seat.

The waste mechanism of the Rife Engine consists of a large port with a flat ample opening and a rather large rubber valve with a balance counterweight and spring seating, removing almost entirely the jar at closing. The valve C in the air chamber consists of a rubber disk with gridiron ports and convex seats, fastened at the center and lifting at the circumference, as shown by Fig. 56. The effort is to transfer the shock from the power of the driving water through the air cushion with the smallest amount of friction and jar.

After closing the valve C the pressure of the air in the air chamber forces the water in the air chamber out into the delivery pipes.

With the Rife Engine the manufacturers claim to elevate water 30 feet for every foot of fall in the driving head. The machine is built in capacities as high as 150,000 gallons per day, and the efficiency of eighty-two per cent is claimed.

The question of efficiency of hydraulic rams has been much discussed, and such authorities as Rankine and D'Aubisson differ considerably in their calculations. The Rife Hydraulic Engine Company uses Rankine's formula in calculating efficiency, which is

$$E = \frac{qh}{(Q-q)\,H},$$

where Q is the quantity of water flowing per second in the drive pipe; q, the quantity flowing per second to the stand-pipe through the discharge pipe; H, the height from the escape valve to the level of the reservoir which feeds the drive pipe; and h, the difference in the level of the water-supply reservoir and the water in the stand-pipe. D'Aubisson states the formula for efficiency as

$$E = \frac{q\,(H + h)}{Q\,H}.$$

D'Aubisson's is the correct one, considering the mechanism as a machine receiving energy at one end and delivering it at the other, while if the machine is considered as elevating water only from the one reservoir to the other, Rankine's formula is the correct one to use.

When a pipe is attached at *H* (Fig. 56), the engine is termed double-acting; spring water, or that which is purer than the water used to drive the engine, may then be supplied through *I*, and by a proper adjustment of the relative flow of the impure driving water, and that of the pure supply, the engine may be made to deliver only the pure water into the mains. This method is used where the supply of pure water is limited.

SIZES OF PIPES FOR HYDRAULIC RAMS.

Quantity of Water Furnished per Minute by Supply to which Ram is Adapted.	Length of Pipe.		Size of Pipe, Inches.	
	Drive.	Discharge.	Drive.	Discharge.
3 quarts to 2 gallons per minute	25 to 50 feet.	Any length desired.	$\frac{3}{4}$	$\frac{3}{8}$
$1\frac{1}{2}$ gallons to 4 gallons per minute			1	$\frac{1}{2}$
3 gallons to 7 gallons per minute			$1\frac{1}{4}$	$\frac{1}{2}$
6 gallons to 14 gallons per minute			2	$\frac{3}{4}$
12 gallons to 25 gallons per minute			$2\frac{1}{2}$	1
20 gallons to 40 gallons per minute			$2\frac{3}{4}$	$1\frac{1}{4}$
25 gallons to 75 gallons per minute			4	2

If the pipes are lead, the drive pipe should be of the "A" grade for diameters up to 2 inches. The discharge pipe, if lead, should be of the "B" grade for rises of 50 feet or less, and "A" grade for rises between 50 and 100 feet. For falls greater than 10 feet and rises of more than 100 feet, the pipe must be heavier than just given. The length of the drive pipe should be from 25–50 feet. If discharge pipe is very long (say one-fourth mile), a larger size than given in the table should be used. With a given supply of water under a great fall, a ram need not be as large as for the same quantity of water under a less fall. When large quantities of water are to be raised, it is better to increase the number of rams in preference to having one of very large capacity.

Several rams may be set so as to deliver into one discharge pipe, each having a separate drive pipe.

To obtain maximum efficiency of ram with any fall, the dash valve should be adjusted to close at the instant the water in the drive pipe has attained its maximum velocity.

Rules for Regulating and Care of Gas Stoves.

The proper way to adjust or regulate an atmospheric gas burner is to open wide the air mixer, and then cut down the gas supply until there is just pressure enough to prevent the gas from lighting back in the mixer, then adjust the air supply so as to give the proper flame. The proper flame is one in which each separate jet at each hole seems to be burning alone by itself, and not touching any of the jets adjoining, and burning with a greenish cone in the center of the jet, the cone having the appearance of a swirling motion.

To clean the burner when incrusted with dirt and grease: boil it in strong lye water, or in bad cases heat to a red heat over a fire.

In adjusting the burner, be sure to see there is no dirt or lint in the mixer, to obstruct the flow of air.

The tops of gas stoves when dirty can be cleaned with gasoline and a stiff brush, but extreme care must be taken that there is no fire in the room, and the room must be thoroughly ventilated after using the gasoline before lighting the gas.

Flange Connections for Heavy Pipe.

Fig. 57 shows several different styles of flanges now made for heavy pipe. 1 is the corrugated face flange made by scoring the face of the flange with a series of concentric rings about $\frac{1}{64}$ inch deep.

This method is not well adapted to thin copper gaskets or to rubber gaskets less than $\frac{1}{16}$ inch in thickness. If rubber gaskets are used with this flange they should be about $\frac{1}{8}$ inch thick.

2 is the ordinary smooth-faced flange with which copper or rubber gaskets are used.

3 is the male and female faced flanges which are made with recessed and projecting faces, which fit into each other. The

male face projects from $\frac{3}{16}$ to $\frac{1}{4}$ of an inch, according to the size of pipe, and extends out from the inner circle of pipe about half way to the bolt holes.

The female face is recessed from $\frac{1}{2}$ to $\frac{3}{16}$ of an inch in depth, according to size, and is made sufficiently large in diameter to receive the male projection without binding or throwing the bolts out of true.

This method forms a very reliable joint, as the ends of the pipe bear on the gasket, thus forming a perfect joint and keeping the steam, water or air from reaching the joints where the flanges are made on the pipe. It is also impossible to blow out the gasket, as it is held firmly in the recess, and the contact is so liberal that there is no danger of the gasket crushing or squeezing out when subjected to extreme heat or pressure.

The only serious objection to this style of flange is the difficulty of opening the line in case it is necessary to renew a gasket or replace a fitting, valve or section of pipe.

4 is the tongued and grooved faced flanges, which are similar to the male and female, with the exception that the projections and recesses do not extend to the inner circle of the pipe, but are very narrow and are situated midway between the bolt holes and the inner circle of the pipe, thus forming only a limited space for the gasket, which in consequence is easily crushed or squeezed out of the recess when placed under severe working conditions. Neither does the gasket cover the ends of the pipe, this omission, of course, allowing the steam, water or air to come in constant contact with the joints where flanges are made on the pipes.

Flanges faced in this manner are subjected to severe strains when the bolts are drawn up, owing to the narrow contact between the faces, and the method has no advantages not possessed by the male and female joint, and many disadvantages. The same objection applies to this style of joint as to the male and female, when it comes to repairs.

5 shows flanges with smooth raised faces, which are made with $\frac{1}{32}$ or $\frac{1}{16}$ inch raised faces inside the bolt holes, and the projecting faces are turned off smooth.

This is a popular method in some parts of the country, and is frequently used for working pressures up to 250 pounds.

It is especially suited for corrugated copper or thin rubber gaskets.

6 shows the raised faced flanges for grinding, which are made with $\frac{1}{32}$ or $\frac{1}{16}$ inch raised faces inside the bolt holes. These faces are finished very smooth in the shops, ready for grinding. When the pipe flanges are put to use they are ground in place by the use of a special grinding or face plate, using energy and oil as a grinding mixture.

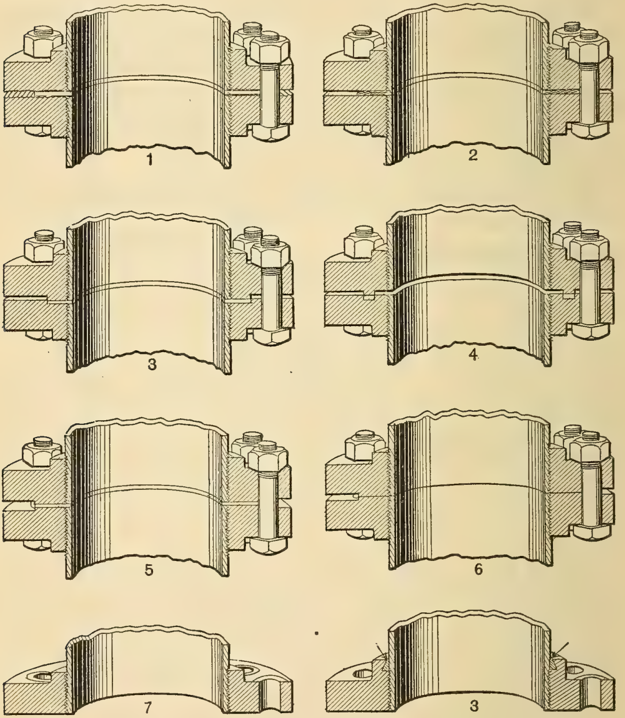


Fig. 57. Methods of Facing Extra Heavy Companion Flanges.

7 shows flanges with spot faced bolt holes, which are made by facing off around the bolt holes on the back side of the flange, where the nut or head of the bolt bears. This is done to give the nuts or heads of the bolts a more true, firm bearing than could

be obtained on the rough casting. It is useless expense, however, to spot face the bolt holes on the flanges, unless the bearing faces of both the heads and nuts of the bolts are faced true also.

8 shows flanges with calking recesses which are made by cutting a recess in the hubs on the back on the flanges. This recess is $\frac{1}{2}$ inch in depth, $\frac{1}{4}$ inch wide at the top and $\frac{5}{16}$ of an inch wide at the bottom. It can be applied to extra heavy flanges in sizes from 2 to 24 inches. Flanges so fitted are $\frac{1}{2}$ inch higher than the regular flanges. When this flange is used for cold water the recesses are filled with lead, which is calked in firmly to prevent the flanges from leaking where they are made on the pipe. When these flanges are used on steam, the recesses are filled with soft copper, which is calked in firmly to keep the flanges from leaking.

Thawing Frozen Water Pipes with Electricity.

Fig. 58 shows an electric thawing apparatus manufactured by The Westinghouse Electric & Manufacturing Co. It is described as follows:

For heavy work, such as street thawing, a specially designed choke coil is used, which is connected in series with the primary of a 2200-volt, 60-cycle, ordinary lighting transformer of from 15 to 25 kilowatt capacity. The primary voltage may be varied from 50, 60, 75, 87, and 95 per cent of the full line voltage by simply changing the position of plugs in the choke coil. Connections are made to two hydrants or fire plugs, or to one hydrant and the pipe to be thawed at a point beyond the frozen part. The choke coil occupies a space of 16×16 inches and weighs 200 pounds. This outfit may be transported either in a sleigh or wagon, or upon a truck.

For pipes in dwellings and other light service the thawing transformer illustrated herewith is used. This transformer is intended for use on 2200-volt, 60-cycle circuits. It has a variation in secondary voltage of from 55 to 53 volts, and will maintain a current of 100 amperes for one-half hour without undue heating. For thawing service pipes the usual method is to connect one terminal to a house faucet and the other to the nearest hydrant, or a faucet in a neighboring house. For thawing street mains, two hydrants may be used. This transformer

weighs only a hundred pounds and may be carried by one man.

The time required for thawing, as well as the voltage or current necessary, vary with the size, location and length of pipe, as well as with the atmospheric temperature. Large pipes require less voltage to force the same current through a given length, but require more current to thaw. Pipe imbedded in solidly frozen ground naturally requires a longer time and more current than a pipe frozen only a part of its length.

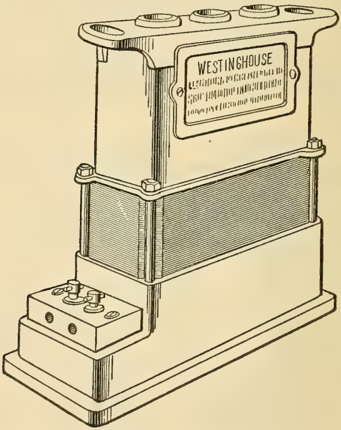


Fig. 58. Electric Thawing Machine.

Five hundred amperes is usually sufficient for pipes up to five inches diameter, while 12-inch mains may require a thousand amperes. For small pipes a much lower current is sufficient. In practice it is found that a small current for a long period of time will do the work that a large current will do in a short time, and with less chance of injury to the pipe. Unless great care is exercised in making connections to the piping system, faucets, hydrants or pipes may be burned and disfigured by the heat developed by the heavy current passing through poor connections.

Following is a tabulation compiled from actual thawing operations, showing the current, voltage and time required to

thaw different sizes and lengths of iron pipe under varying conditions:

Diameter in Inches.	Length in Feet.	Amperes.	Volts.	Time Required.
				5 min.
½	50	250	20	15 "
½	70	300	16	45 "
½	100	150	20	45 "
¾	80	300	110	23 "
¾	100	135	55	10 "
¾	240	250	52	30 "
¾	380	300	30	10 "
1	45	140	220	17 "
1	250	500	50	20 "
1	600	60	50	1 hr.
1	700	175	55	5 "
2	20	2000	6	3 "
2	50	500	50	2 "
2	60	160	50	4 "
2	300	250	52	2 " 30 "
4	800	300	50	3 "
6	400	800	110	2 " 10 "

The cost to the customer of thawing by electricity varies in different cities from five to fifteen dollars, when a price is made for the job. In some cities the cost is based upon the time required for the operation, a minimum charge being made for the first hour and a fixed charge for each additional hour.

To Read an Electric Meter.

Fig. 59 is a facsimile of the dial plate of a Thomson Recording Watt Meter. The figures under each dial represent the amount of a complete revolution of the hand of that dial.

A complete revolution of a hand of any dial is represented by one of the sub-divisions of the next dial to the left. Thus each sub-division of the lower right hand dial represents 100, and one complete revolution of the hand of that dial represents 1,000, and is registered by the next dial to the left and represented by one of its sub-divisions, and so on through the series of dials.

The first dial, or the one at the extreme right, reads 700; the second dial indicates 9000; the third dial indicates 90,000, the

indicator being on 0, but as the second dial reads 9000 and has not completed its revolution the third dial must be read 9000.

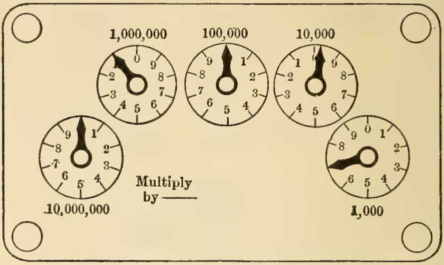


Fig. 59. Dial Plate of Electric Meter.

The fourth dial is not counted, for until the third dial is read 100,000 the figure 1 in the fourth dial can not be used. Thus we have the reading of the dial: —

	700	from the first dial.
	9,000	from the second dial.
	90,000	from the third dial.
Total	99,700	

Or reading the dials from right to left and putting the figures down right to left the reading will be the same.

To obtain the correct reading of the meter, multiply by the factor given on the dial plate.

Water Meters, to Read, Test, etc.

Fig. 60 and 61 are facsimiles of the dial plate of a Crown meter. They register cubic feet, one cubic foot being $7\frac{48}{100}$ U. S. gallons, and are read the same way as explained for the reading of the electric meter.

If the pointer be between two figures, the lesser must always be taken. When a pointer is so near a figure that it seems to indicate it exactly, look at the circle next lower in number, and, if the pointer in that circle has passed "0" then the count should be read for the figure indicated by the higher circle.

If the first circle is marked "100" it is necessary to add one cipher for the 10's place. Each division of any circle stands for $\frac{1}{10}$ of the whole number indicated by that circle.

For example, let it be supposed that the pointers stand as in Fig. 60 then the reading would be 94,450 cubic feet. The figures are omitted from the dial marked "One" because they represent but tenths of one cubic foot, and hence are unimportant. From the dial marked "10" we get 0; from the next dial marked "100" we get 5, and from the next dial marked "1000" we get 4; from the next marked "10,000" we also get 4; from the next marked "100,000" we get the figure 9. Placing the figures as we have taken them from right to left we get the reading 94,450.

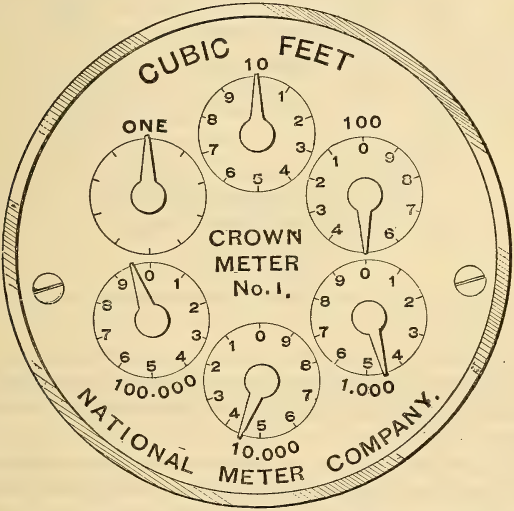


Fig. 60. Dial of Water Meter, Reading 94,450 Cubic Feet.

The correct reading of Fig. 61 is 91,692,480 cubic feet. As the lowest circle in this dial begins with 100, it is necessary to add one "0" for the 10's place.

How to Test Meters. — Whenever possible, all meters should be tested by weighing the water, allowing $62\frac{1}{2}$ pounds to the foot.

It is necessary to run at least one complete revolution of the first circle of the meter dial in all tests, as the divisions in the circle may not be graduated exactly.

When it is necessary to make a series of runs to complete one revolution of the first circle, the total weight of the several runs should be added, and in no case should sub-divisions of the circle be used to calculate the accuracy of the meter.

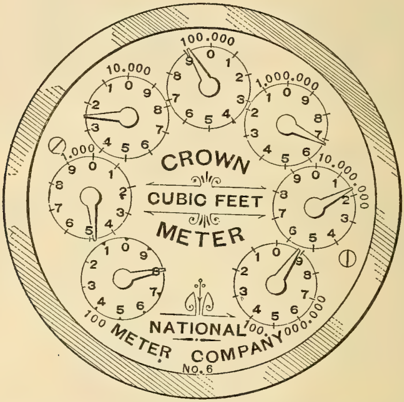


Fig. 61. Dial of Water Meter, Reading 91,692,480 Cubic Feet.

When testing a meter, the reducing faucet should be placed on the outlet side of a meter, thus maintaining a pressure on the meter and making the conditions of test similar to that of actual service.

When competitive tests are to be made of several meters, each meter should be tested for accuracy before being placed in service, and the same water should flow through all the meters, reversing their order whenever removed for additional tests.

Instructions for Setting Meters. — In setting a meter in position, let it be plumb, and properly secured to remain so. It should be well protected from frost.

If used in connection with a steam boiler, or under any other conditions where it is exposed to a back pressure of steam or hot water, it must be protected by a check valve, placed between the outlet of the meter and the vessel it supplies.

It is absolutely necessary to blow out the supply pipe before setting a new meter, so that, if there be any accumulation of sand, gravel, etc., in it, the same may be expelled, and thus prevented from entering the meter. Avoid using red lead in making joints. It is liable to work into the meter and cause much annoyance by clogging the piston.

Properties of Lead.*

Lead is a bluish gray metal.

Does not crystallize readily. When refined lead is poured at the correct temperature into a warm mould and allowed to cool, fern-like crystalline aggregates appear at the surface.

It is the heaviest of all metals.

Specific gravity 11.37 (Reichs) for pure lead at 0° C. (water at 4° C. being unity). Roberts-Austen gives as specific gravity of solid lead 11.40; of liquid lead 10.65 and 10.67. The specific gravity will vary slightly according as it is cooled quickly or slowly, hammered or rolled.

Commercial lead has a lower specific gravity than 11.37 on account of the impurities contained in it.

Lead is very soft, especially when allowed to cool and solidify slowly.

Lead is very malleable and ductile.

Fracture of lead is hackly when broken cold, columnar when hot.

In the form of filings it becomes a solid mass if subjected to a pressure of 13 tons to the square inch and liquefies at $2\frac{1}{2}$ times this pressure (Roberts-Austen).

Oxidation occurs slowly in dry air, the oxide forming a protecting coating over the surface.

Lead undergoes no change in perfectly dry air, nor in water that is free from air.

If melted in contact with air it oxidizes and becomes covered with an iridescent pellicle said to be the suboxide Pb_2O; this gradually changes to the oxide PbO, and if the heating to from 300° to 450° C. be prolonged sufficiently the red oxide Pb_3O_4 is obtained.

The other two oxides which lead forms are the sesquioxide Pb_2O_3 and the peroxide PbO_2.

* Catalogue of Colwell Lead Company.

Lead melts at about 625° F. (330° C.) and softens and becomes pasty at about 617° F. (Kent.)

Lead absorbs in fusing 5.4 metric thermal units per kilogramme.

Lead is readily dissolved in water containing carbonic acid or salts of nitric acid; the solution is poisonous.

Lead boils at between 1450° and 1600° C.

Lead cannot be distilled.

Lead emits a vapor at a bright red heat of almost $\frac{1}{100}$ of its weight per hour.

Latent heat of lead is 5.369.

Atomic weight 206.9.

Expansion at ordinary temperatures.

Coefficient for 1° F., 0.00001571.

Total between 32° and 212° F. Coeff. = 0.002828.

Coefficient of cubical dilation for 1° C.; 0.000089.

Linear coefficient about $\frac{1}{3}$ of the cubical.

Heat conducting power of lead is about 85. (Weidemann & Franz.)

Specific heat between 10° and 100° C. is 0.0314, with silver as 100, the conductivity for heat at 12° C. is 8.5, and for electricity 10.7.

Breaking strength in tons per square inch (cast), lead .81, sheet lead .86, lead pipe 1.00.

Average ultimate tensile strength for cast lead 1700 to 2400 pounds per square inch; for lead wire 1200 to 1600; for lead pipe 1600 to 1700.

Average crushing load per square inch (cast) 7350 pounds.

Shrinkage of castings in 1 foot $\frac{5}{16}$ inch.

Tensile resistance 2240 pounds.

Safe working tension 370.

Lead is almost devoid of elasticity.

Sheet lead has a tenacity or resistance to tearing by direct pull of 3300 pounds per square inch.

Properties of Tin.

Tin when pure has a specific gravity of 7.28 to 7.4, the purest being the lightest.

Atomic weight is 119.

Coefficient of expansion is .000023.

Melting point is 443° F. (232° C.).

Boils at a white heat.

Specific heat is .0562.

Latent heat of fusion is 25.65 B.T.U. per pound.

Conductivity is low.

Oxidizes slowly in the air at ordinary temperatures.

Burns quite freely at a white heat and with a white flame.

Exposed to extreme cold it becomes crystalline.

Breaking strength in tons per square inch for cast tin, 2.

Heat conducting power, 14.5.

Weight per cubic foot, 459 pounds.

Average ultimate tensile strength, 3500 pounds per square inch.

Average crushing load per square inch cast tin, 15,500 pounds.

FORMULA AND RULES FOR LEAD PIPE. — To find the thickness of a lead pipe when the head is known:

Rule. — Multiply the head in feet by size of pipe wanted, expressed decimally, and divide by 750; the quotient will give the thickness required in one-hundredths of an inch. (Kent).

Example. — Required thickness of $\frac{1}{2}$ inch pipe for head of 25 feet. Thickness equals $25 \times 0.50 \div 750 = .16$ of an inch.

To compute maximum or bursting pressure that may be borne by a lead pipe.

Multiply the tensile resistance of the metal in pounds per square inch by twice thickness of pipe and divide the product by internal diameter, both in inches. (Colwell Lead Co.)

Example. — What is the bursting pressure of lead pipe 3 inches in diameter, .5 inch thick? (See table of properties, p. 116, for tensile resistance.)

$$\frac{2240\ (.5 \times 2)}{3} = \frac{2240}{3} = 746.6 \text{ lbs.}$$

To ascertain the weight of lead pipe, diameter and thickness of metal being given. (Winslow.)

Rule. — Multiply the square of its exterior diameter in inches by the weight of 12 cylindrical inches, then multiply the square of its interior diameter in inches by the same factor, subtracting the product of the latter from that of the former; the remainder will be the weight.

The weight of 12 cylindrical inches (1 foot long and 1 inch diameter) of lead is 3.8697 pounds.

Example. — Required the weight of a lead pipe 1200 feet long, $\frac{7}{8}$ inch outside diameter, $\frac{9}{16}$ inch inside diameter.

$\frac{7}{8} \times \frac{7}{8} = \frac{49}{64} = 0.765625.$

$\frac{9}{16} \times \frac{9}{16} = \frac{81}{256} = 0.316406.$

$0.765625 - 0.316406 = 0.449219 \times 3.8697 \times 1200 = 2086$ pounds.

Lead Memorandum. — Joints in lead pipe require a pound of solder for every inch in diameter.

For flashings use 4 pound sheet lead.

For hips and ridges use 6 pound sheet lead.

For roofs and gutters use 7 pound sheet lead.

Cubic foot of lead weighs 711 pounds.

Cubic inch of lead weighs $6\frac{7}{12}$ ounces.

Sheet lead. Pounds per square foot $\times$ .016 = thickness in decimals of an inch.

All lead traps and bends should be of the same thickness and weight as their corresponding pipe branches.

A fodder of lead equals $91\frac{1}{2}$ cwt.

Lead rolled 1 inch thick by 1 foot square weighs an average of 60 pounds.

Stowage capacity required per ton of lead 4 cubic feet.

Effects of Acids and Other Chemicals on Lead.* — Sulphuric Acid. The purer the lead the less will it be attacked by pure or nitrous sulphuric acid up to about 400° F., the highest temperature employed under normal conditions in concentrating pans; above 400° F. the action becomes stronger and at about 468° F. the lead is dissolved. Concentrated nitrous sulphuric acid acts at all temperatures more powerfully than pure sulphuric acid, and the effect is greater in the presence of air. Dilute nitrous sulphuric acid of a specific gravity of 1.72 to 1.76 is not as powerful as the pure acid, although if the dilution be continued beyond this point the power increases again instead of diminishing. Boiling sulphuric acid of specific gravity 1.84 acts severely on lead and fuming acid still more so.

Jounge found that a rough surface was more readily corroded by nitrous sulphuric acid than a smooth surface, and the greater the content of nitrogen oxides in the acid the more the lead is attacked.

* Catalogue of the Colwell Lead Company, New York.

Organic Acids. — Acetic, tartaric and citric acids attack lead in contact with air.

Nitric acid dissolves lead, forming nitrate of lead. This acid acts very energetically when dilute, but more slowly when concentrated, owing to the nitrate of lead being insoluble in strong nitric acid.

Hydrochloric acid has practically no action on lead. Boiling concentrated hydrochloric and sulphuric acid of 66° F., or specific gravity of 1.77°, dissolve it slowly.

Aqua regia converts lead into a chloride.

Arsenic or arsenious acid unites with lead, yielding arsenite or arsenide of lead.

Peat acids in water rapidly dissolve lead.

Chlorate of potash dried upon lead covered tables will be found to contain traces of lead.

Gases of a properly worked sulphuric acid plant have a very mild action upon the sheet lead of which the chambers are built, and when any severe action takes place some abnormal condition is sure to have been the cause.

Chlorine does not attack lead to any serious extent, but when chlorine is accompanied by traces of hydrochloric gas the damage is often extensive.

Lime wash upon lead after having dried helps chlorine to form the purple oxide of lead. This shortens the life of the lead, and should not be used on the outside of bleaching powder chambers.

Meaning of Horse Power.

The measurement of a horse's power for work was first ascertained by Watt, the father of the modern steam engine, and he expressed this in terms that hold to this day. He experimented with a great number of brewery horses to satisfy himself that his unit of measurement for work was correct. After many trials he found that the average horse was doing work equal to that required to raise 330 pounds of weight 100 feet high in one minute or 33,000 pounds one foot high in one minute; so he called this one horse power.

This work, however, is not continuous, for the horse would have to back up after each pull to lower the line of the pulley, and thus he would work half the time in pulling 330 pounds in the air at the rate of 100 feet in a minute, and the other half

of the time in slacking up the rope. Consequently no horse can actually perform continuously what is generally called one horse power.

There is no horse that could tug at a rope for eight hours a day, pulling 330 pounds, 100 feet each minute, without rest or change.

So when we speak of horse power we refer only to the average work a horse can do in one minute, that is to say, the rate at which he can work.

To Find Horse Power of an Engine. —

a equals Area of piston in square inches.
p " Mean pressure of the steam on the piston per square inch.
v " Velocity of piston per minute in feet.

Then H. P. equals $\frac{a \times p \times v}{3000}$

The mean pressure in the cylinder when cutting off at

$\frac{1}{4}$	Stroke	equals	boiler	pressure	× .597
$\frac{1}{3}$	"	"	"	"	× .670
$\frac{3}{8}$	"	"	"	"	× .743
$\frac{1}{2}$	"	"	"	"	× .847
$\frac{5}{8}$	"	"	"	"	× .919
$\frac{2}{3}$	"	"	"	"	× .937
$\frac{3}{4}$	"	"	"	"	× .966
$\frac{7}{8}$	"	"	"	"	× .992

To find the weight of the rim of the fly wheel for an engine:

$\frac{\text{Nominal H. P.} \times 2000}{\text{The square of the velocity of the circumference in feet per second.}}$ equals weight in cwts.

Relative Value of Heating Surface. —

Horizontal surfaces above the flame equal	1.00
Vertical surfaces above the flame equal	.50
Horizontal surfaces beneath the flame	.10

Tubes and Flues equal $1\frac{1}{4}$ times their diameter.
Convex surfaces above the flame equal $1\frac{1}{6}$ diameter.

FEED WATER REQUIRED BY SMALL ENGINES.

Gauge Pressure at Boiler.	Lbs. Water per Effective H.P. per Hour.	Gauge Pressure at Boiler.	Lbs. Water per Effective H.P. per Hour.
10	118	60	75
15	111	70	71
20	105	80	68
25	100	90	65
30	93	100	63
40	84	120	61
50	79	150	58

Making Brass and Lead Pipe.

As a majority of plumbers are not familiar with the way brass and lead pipe are made the following description as given in *Valve World* is given.

Brass. — The raw materials for brass tubing, about one-third spelter (unrolled zinc) and two-thirds copper, are first melted in a crucible. The proportions of this mixture may be varied according to the quality of tube desired. After being thus melted and mixed the composition is poured into a mold and around a bar that is supported in the mold, thus producing a hollow casting. This casting when cooled is removed from the mold and taken to the drawing room. The machine for drawing the tubing has somewhat the appearance of a long trough. In the center of it is permanently fastened a support for holding a die, through which the casting is drawn, the outside of the tubing being thus formed. The inside of the tubing is formed by a mandrel of proper size placed inside the casting, this mandrel being held in position by a long bar. The casting is clutched on one end by a clamp, or "dog," as it is called, and is then drawn through the die and over the mandrel, which operation reduces its size and at the same time gives it a finish. This drawing process is repeated again and again, each time through a smaller die, until the tubing is brought down to the diameter and thickness required. As drawing has the effect of hardening the metal it is necessary that the tubing should be annealed after each drawing, otherwise it would become so hard and brittle

as to break while being drawn. Annealing consists in heating the metal to a red heat and then allowing it to cool gradually.

Lead. — The machine by which this work is performed is composed of a hydraulic cylinder and a lead cylinder. In the hydraulic cylinder is what is called a "water ram," and on top of this water ram is placed the lead cylinder, the hydraulic pressure being applied at the bottom of the water ram. In the center of the lead cylinder is a steel core, and as the melted lead is run into this lead cylinder it congeals, forming a solid mass around the steel core. A lead ram is hung directly over the lead cylinder, fitting it exactly, and in the bottom of this ram is a die, having in its center a hole the exact size of the outside of the pipe. It will be seen that by this arrangement the space which is left between the center core in the lead cylinder and the die above it is just the thickness and size of the pipe that is to be made. After the lead has been melted and run into the cylinder and has congealed the hydraulic pressure is applied in the cylinder, which raises the lead cylinder up against the lead ram, (which ram it will be remembered fits the lead cylinder exactly). The pressure applied is so great (sometimes being as high as 28,000 pounds to the square inch) that it forces the congealed lead to flow out in a "stream," as it might be called, which completely fills the space between the steel core and the die, the latter forming the outside of the pipe, while the former makes the inside. As the pipe comes out of the machine it is coiled up and is then ready to use.

TABLES OF RADIATION.

TAPPING OF RADIATORS.

HEIGHT FROM FLOOR TO CENTER OF TAPPING OF VARIOUS SINGLE-COLUMN RADIATORS.

National and Peerless. — Distance from floor to center of tapping is $4\frac{1}{2}$ inches, for both steam and water (except in 32-, 26-, 23-, and 20-inch heights, where tapping is $\frac{3}{4}$-inch, the distance is $4\frac{1}{8}$ inches).

Buffalo Standard and St. Louis Standard. — Distance from floor to center of tapping in single pipe, steam, is 5 inches (except 2-inch tapping, in which case the distance is $5\frac{1}{2}$ inches; double pipe steam, $5\frac{1}{2}$ inches for supply, 5 inches for return; water, both supply and return $5\frac{1}{2}$ inches.

Italian Flue. — Distance from floor to center of supply tapping: single-pipe steam, 4 inches; double-pipe steam, $4\frac{1}{2}$ inches supply and 4 inches for return; water, $4\frac{1}{2}$ inches for both supply and return.

Niagara Junior. — Distance from floor to center of tapping is 5 inches for both steam and water.

Zenith. — Distance from floor to center of tapping: single-pipe steam, $4\frac{1}{2}$ inches; double-pipe steam, supply $4\frac{3}{4}$ inches, return $4\frac{1}{4}$ inches; water, both supply and return $4\frac{3}{4}$ inches.

Triton, Roman and Calor. — Distance from floor to center of tapping is $4\frac{1}{2}$ inches.

Webster Sheet Steel. — Distance from floor to center of tapping is $6\frac{1}{2}$ inches.

Kinnear Sheet Steel. — Distance from floor to center of tapping is 4 inches.

DISTANCE FROM FLOOR TO CENTER OF TAPPING OF VARIOUS TWO-COLUMN RADIATORS.

Astro, Shirley, Breemen, Calor and Reliance. — Distance from floor to center of tapping is $4\frac{1}{2}$ inches.

Buena and Kinnear Sheet Steel. — Distance from floor to center of tapping is 4 inches.

Acme, Buffalo Standard, National, Peerless and Perfection Ornamental. — Distance from floor to center of tapping in single-pipe steam is 4 inches; for two-pipe steam, supply $4\frac{1}{2}$ inches and return 4 inches; for water, both supply and return $4\frac{1}{2}$ inches.

Ideal. — Distance from floor to center of tapping; single-pipe steam, 4 inches; double-pipe steam, supply $4\frac{1}{2}$ inches, return 4 inches. In other than 38-inch height, distance from floor to center of tapping, either supply or return, is $4\frac{1}{2}$ inches, except where $\frac{3}{4}$-inch tapping is required, in which case the distance is $4\frac{1}{8}$ inches.

Ducol. — Distance from floor to center of tapping is: $\frac{3}{4}$-inch tapping, $3\frac{2}{3}$ inches; 1-inch tapping, 4 inches; $1\frac{1}{4}$-inch tapping, $4\frac{1}{8}$ inches; $1\frac{1}{2}$-inch tapping, $4\frac{1}{4}$ inches; 2-inch tapping, $4\frac{5}{8}$ inches.

Niagara, Colonial, Scepter and Tiara. — Distance from floor to center of tapping is 5 inches both steam and water.

Perfection (steam). — Distance from floor to center of tapping; single-pipe steam, 4 inches; double-pipe steam, supply $4\frac{1}{2}$ inches, return 4 inches.

Rising Sun. — Distance from floor to center of tapping is $6\frac{1}{2}$ inches.

St. Louis Standard. — Distance from floor to center of tapping in single-pipe steam is 4 inches (except 2-inch tapping, in which case tapping is $4\frac{1}{2}$ inches); two-pipe steam, $4\frac{1}{2}$ inches supply, 4 inches return; for water, $4\frac{1}{2}$ inches supply or return.

Solus. — Distance from floor to bottom of tapping for one pipe, or return end of two-pipe work, $3\frac{1}{2}$ inches. From floor to center of tapping on feed end for two-pipe work, $4\frac{3}{4}$ inches.

Triton and Chautauqua. — Distance from floor to center of tapping is $4\frac{1}{8}$ inches.

Roman. — Distance from floor to center of tapping is $4\frac{1}{4}$ inches.

Solar. — Distance from floor to center of tapping is $3\frac{3}{4}$ inches.

Coronet and Diadem. — Distance from floor to center of tapping is $4\frac{3}{16}$ inches for 2-inch tapping; $4\frac{1}{16}$ inches for $1\frac{1}{2}$-inch tapping; $3\frac{11}{16}$ inches for $1\frac{1}{4}$-inch tapping; $3\frac{13}{16}$ inches for 1-inch tapping, and $3\frac{11}{16}$ inches for $\frac{3}{4}$-inch tapping.

Sun. — Distance from floor to bottom of tapping is $4\frac{1}{2}$ inches.

DISTANCE FROM FLOOR TO CENTER OF TAPPING OF VARIOUS THREE-COLUMN RADIATORS.

Bon-Ton. — Distance from floor to center of tapping is $6\frac{1}{2}$ inches.

Corinth. — Distance from floor to center of tapping: One-pipe, steam drop hub, $4\frac{3}{4}$ inches, on 18-inch height this distance is $2\frac{3}{4}$ inches; two-pipe, steam drop hub, supply $5\frac{1}{4}$ inches, return $4\frac{3}{4}$ inches, on 18-inch height these distances are $3\frac{1}{4}$ and $2\frac{3}{4}$ inches, respectively. Hot water, floor to center of tapping is $5\frac{1}{4}$ inches, on 18-inch height this distance is $3\frac{1}{4}$ inches.

Buena, Tremont, Duet and Narrow. — Distance from floor to center of tapping is 4 inches.

Buffalo. — Distance from floor to center of tapping in single-pipe steam is 5 inches; two-pipe steam, supply is $5\frac{1}{2}$ inches, return 5 inches.

Peerless, Rococo, Puritan and Florentine. — Distance from floor to center of either supply or return tapping is $4\frac{1}{2}$ inches for water; 4 inches for single-pipe steam; $4\frac{1}{2}$ inches supply, 4 inches return, for double-pipe steam.

Premier. — Distance from floor to center of supply openings is 4 inches for single-pipe steam; $4\frac{1}{2}$ inches supply, 4 inches return

for double-pipe steam; $4\frac{1}{2}$ inches, either supply or return, for water.

NIAGARA. — Distance from floor to center of tapping is 5 inches for water and $4\frac{1}{2}$ inches for steam.

RINGEN, ECLIPSE, ROYAL UNION AND SOVEREIGN UNION. — Distance from floor to center for tapping is 5 inches.

ST. LOUIS STANDARD. — Distance from floor to center of tapping, in single-pipe work, is 5 inches (except 2-inch tapping, in which case distance is $5\frac{1}{2}$ inches); two-pipe steam, supply $5\frac{1}{2}$ inches, return 5 inches; for water, either supply or return, $5\frac{1}{2}$ inches.

SHIRLEY, ROMAN, IMPERIAL UNION, PRINCESS UNION, SUN, CALOR, MERCURY, AND TRITON. — Distance from floor to center of tapping is $4\frac{1}{2}$ inches.

SENECA. — All tappings except 14- and 18-inch heights are $5\frac{1}{4}$ inches from floor to center of tappings; 14- and 18-inch heights are $3\frac{1}{4}$ inches from floor to center of tapping.

TRICOL. — Distance from floor to center of tapping is: $3\frac{3}{4}$ inches for $\frac{3}{4}$-inch tapping; $3\frac{2}{3}$ inches for 1-inch tapping; 4 inches for $1\frac{1}{4}$-inch tapping; $4\frac{1}{8}$ inches for $1\frac{1}{2}$-inch tapping and $4\frac{1}{2}$ inches for 2-inch tapping

KEWANEE. — Distances from floor to center of tapping.

One-pipe steam, *drop hub*, $4\frac{1}{2}$ inches; on 18-inch height this distance is $2\frac{1}{2}$ inches.

Two-pipe steam, *drop hub*, supply 5 inches, return $4\frac{1}{2}$ inches; on 18-inch height these distances are 3 inches and $2\frac{1}{2}$ inches, respectively.

Hot water, floor to center, 5 inches; on 18-inch height this distance is 3 inches.

SOLUS. — Distance from floor to bottom of tapping for one-pipe, or return end of two-pipe work, $4\frac{1}{8}$ inches. From floor to center of tapping on feed end for two-pipe work, $5\frac{1}{4}$ inches.

IMPERIAL UNION. — Distance from floor to center of tapping is $4\frac{5}{8}$ inches for 2-inch tapping; $4\frac{1}{2}$ inches for $1\frac{1}{2}$-inch tapping; $4\frac{3}{8}$ inches for $1\frac{1}{4}$-inch tapping; $4\frac{1}{4}$ inches for 1-inch tapping, and $4\frac{1}{8}$ inches for $\frac{3}{4}$-inch tapping (except for the 19-inch height, in which the tapping is $\frac{1}{8}$-inch higher than in the other heights).

PRINCESS UNION. — Distance from floor to center of tapping is $4\frac{11}{16}$ inches for 2-inch tapping; $4\frac{9}{16}$ inches for $1\frac{1}{2}$-inch tapping; $4\frac{7}{16}$ inches for $1\frac{1}{4}$-inch tapping; $4\frac{5}{16}$ inches for 1-inch tapping, and $4\frac{3}{16}$ inches for $\frac{3}{4}$-inch tapping.

DISTANCE FROM FLOOR TO CENTER OF TAPPING OF VARIOUS FOUR- AND FIVE-COLUMN RADIATORS.

BUENA. — Distance from floor to center of tapping is 4 inches.

BUFFALO STANDARD AND ST. LOUIS STANDARD. — Distance from floor to center of tapping in single-pipe work is 5 inches (except 2-inch tapping of St. Louis Standard, in which case distance is $5\frac{1}{2}$ inches); for two-pipe steam, supply $5\frac{1}{2}$ inches, return 5 inches; for water, either supply or return, $5\frac{1}{2}$ inches.

NATIONAL, PEERLESS, CELOR AND TRITON. — Distance from floor to center is $4\frac{1}{2}$ inches.

SENECA. — Tapping is the same as for Seneca Three Column.

SOLUS FIVE COLUMN RADIATOR. — Distance from floor to center of tapping for water or feed end of two-pipe steam, 5 inches; from floor to bottom of tapping for one-pipe steam or return end of two-pipe steam, 4 inches.

Distance from floor to center of tapping of various window radiators.

BUENA. — Distance from floor to center is 3 inches.

ST. LOUIS. — Distance from floor to center of tapping on single-pipe work is 3 inches (except 2-inch tapping, in which case distance is $3\frac{1}{2}$ inches); for two-pipe steam, supply $3\frac{1}{2}$ inches, return 3 inches; for water, either supply or return, $3\frac{1}{2}$ inches.

UTILITY. — Distance from floor to center of tapping is $3\frac{1}{2}$ inches.

FEDERAL. — Distance from floor to bottom of tapping, $2\frac{1}{2}$ inches, and on 13-inch height this distance is $1\frac{1}{2}$ inches.

SOLUS. — Distance from floor to center of tapping for water or feed end of two-pipe steam, $2\frac{1}{4}$ inches; from floor to bottom of tapping for one-pipe steam or return end of two-pipe steam, $1\frac{1}{4}$ inches.

HEATING SURFACE OF RADIATORS.

The following tables give the name, size and heating surface per section of the various radiators made by the different manufacturers.

Tables of Radiation.

HEATING SURFACE OF RADIATORS.

Square feet of heating surface per section of single-column radiators.

Height in inches		44	40	38	33	32	31	30	28	26	23	22	20	19	18
Manufacturer.	Name of Radiator.	Square feet of heating surface per section.													
American Radiator Company.	Buffalo St'd ornamental	$3\frac{1}{2}$	....	3	....	$2\frac{1}{2}$	....	....	....	2	....	$1\frac{5}{8}$	$1\frac{1}{2}$	....	$1\frac{1}{4}$
	Plain steam	$3\frac{1}{2}$	....	3	....	....	....	....	....	2	....	....	$1\frac{1}{2}$	....	....
	Plain water	....	....		....	$2\frac{1}{2}$	....	....	....	2	....	$1\frac{5}{8}$	....	....	....
	National	....	....	3	....	$2\frac{1}{2}$	....	....	....	2	$1\frac{2}{3}$	....	$1\frac{1}{2}$	....	....
	Peerless	....	....	3	....	$2\frac{1}{2}$	....	....	....	2	$1\frac{2}{3}$	....	$1\frac{1}{2}$	....	....
	St. Louis St'd ornamental	$3\frac{1}{2}$	....	3	....	$2\frac{1}{2}$	....	....	....	2	....	....	....	....	....
	....do....plain	....	....	3	....	....	....	....	....	....	....	....	....	....	....
	Zenith Narrow	....	....	$4\frac{1}{2}$	4	....	....	....	$3\frac{1}{2}$	....	$2\frac{3}{4}$	....	....	....	....
Gurney Mfg. Co	Narrow	....	....	4	1	....	....	....	....	....	....	....	....	....	....
Holland Rad. Co.	Calor	....	....	3	....	$2\frac{1}{2}$	....	....	....	2	$1\frac{2}{3}$	....	$1\frac{1}{2}$	....	....
Mott Mfg. Co	Roman	....	....	3	....	$2\frac{1}{2}$	....	....	....	2	....	....	....	....	....
Rumsey Mfg. Co	Niagara Jr	....	4	....	....	3	....	....	....	$2\frac{1}{2}$	....	....	....	....	....
U. S. Radiator Co	Triton	....	....	3	....	$2\frac{1}{2}$	....	....	....	2	....	....	$1\frac{1}{2}$	....	....
Webster Mfg. Co	Sheet Steel	....	....	6	....	....	....	....	....	....	....	....	....	....	....
Kinnear Radiator Co.	Sheet Steel	....	....	....	....	$2\frac{1}{6}$	....	....	....	$1\frac{3}{4}$	....	....	$1\frac{1}{2}$	....	....

Tables of Radiation.

HEATING SURFACE OF RADIATORS.

Square feet of heating surface per section of two-column radiators.

Height in inches		45	44	40	38	32	31	30	26	25	24	23	22	20	19	18	15
Manufacturer.	Name of Radiator.	Square Feet of Heating Surface per Section.															
American Radiator Company	Buffalo St'd	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	....	....	2	....	....	....
	Excelsior	....	....	....	4	....	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	$2\frac{1}{3}$	....	2	....	....
	Favorite	5	....	....	4	....	....	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	....	....	2	....
	Ideal	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	$2\frac{1}{3}$	....	2	....	....	....
	National	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	$2\frac{1}{3}$	....	2	....	....	....
	Peerless	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	$2\frac{1}{3}$	....	2	....	....	$1\frac{1}{2}$
	Perfection — steam	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	$2\frac{1}{3}$	....	2	....	....	....
	do...water	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	....	....	2	....	....	....
	St. Louis St'd	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	....	....	2	....	....	....
	Verona	....	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	....	....	2	....	....	....
	Astro	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	....	....	2	....	....	....
Holland Rad. Co.	Bremen	....	6	$5\frac{1}{4}$	....	4	....	....	....	$3\frac{1}{3}$	....	....	....	$2\frac{3}{4}$	....	....	....
	Reliance	5	....	....	4	....	....	$3\frac{1}{3}$	....	$2\frac{2}{3}$	....	....	....	2	....	....	....
	Calor	5	....	....	4	....	....	$3\frac{1}{3}$	....	$2\frac{2}{3}$	....	$2\frac{1}{3}$	....	2	....	....	....
Kewanau B. Co.	Acme	5	....	....	4	....	....	$3\frac{1}{3}$	$2\frac{2}{3}$	....	....	....	....	2	....	2	....
Kinnear Rad. Co.	Sheet Steel	....	....	....	7	$5\frac{3}{4}$	....	....	$4\frac{1}{2}$	....	....	....	....	$3\frac{1}{2}$	....	....	....

Mott Mfg. Co....	Roman.......	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	....	....	2	....	....	....
	Solar.........	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	....	....	....	....	....	....
	Fluted........	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	....	....	2	....	....	....
	Star..........	....	....	....	7	....	....	....	5	....	....	....	....	4	....	....	3
Clow Mfg. Co.....	Buena........	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	$2\frac{1}{3}$	....	....	....	....	....
M'Lain Mfg. Co..	Seneca.......	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	....	....	2	....	....	....
Nat. Rad. Co. ...	Solus	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	$2\frac{1}{3}$	....	2	....	....	....
Gurney Mfg. Co. .	Duet.........	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	$2\frac{1}{3}$	....	2	....	....	....
Rumsey Mfg. Co .	Niagara......	....	....	4	....	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	....	....	2	....	....	....
Reading Rad. Co.	Ducol........	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	....	....	2	....	....	....
Reliance Heater Co.	Sun..........	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	$2\frac{1}{3}$	....	2	....	....	....
Shirley Rad. Co..	Shirley.......	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	$2\frac{1}{3}$	....	2	....	....	....
South Park Foundry Co.	Rising Sun...	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{1}{2}$	....	....	....	....	2	....	$1\frac{3}{4}$	....
U. S. Rad. Co...	Triton	5	....	....	4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	$2\frac{1}{3}$	....	2	....	$1\frac{3}{4}$	....
	Chautauqua..	5			4	$3\frac{1}{3}$	....	....	$2\frac{2}{3}$	....	....	....	....	2	....	....	....
J. B. Smith Co..	Coronet......	$4\frac{1}{2}$	....	....	$3\frac{1}{2}$	....	3	....	....	$2\frac{1}{2}$	....	....	....	....	2	....	....
	Diadem ...	$4\frac{1}{2}$	....	....	$3\frac{1}{2}$	....	3	....	....	$2\frac{1}{2}$	....	....	....	....	2	....	....
	Scepter.......	....	$4\frac{3}{4}$	....	4	....	....	3	....	....	$2\frac{1}{3}$	....	....	....	....	$1\frac{2}{3}$	....
	Tiara.........	....	$4\frac{3}{4}$	....	4	....	....	3	....	....	$2\frac{1}{3}$	....	....	....	....	$1\frac{2}{3}$	....
	Crown........	$4\frac{1}{2}$	....	....	$3\frac{1}{2}$	....	3	....	....	$2\frac{1}{2}$	....	....	....	....	2	....	....

Tables of Radiation.

HEATING SURFACE OF RADIATORS.

Square feet of heating surface per section of three-column radiators.

Height in inches		45	44	40	38	33	32	28	26	25	23	22	20	19	18
Manufacturer.	Name of Radiator.	Square Feet of Heating Surface per Section.													
American Radiator Co.	Buffalo St'd	....	6	....	5	....	$4\frac{1}{2}$	....	$3\frac{3}{4}$	....	....	3	$2\frac{3}{4}$	....	$2\frac{1}{4}$
	Peerless	....	....	....	5	....	....	....	$3\frac{3}{4}$	....	....	....	....	....	....
	Rococo	....	6	....	5	....	$4\frac{1}{2}$	....	$3\frac{3}{4}$	....	....	3	....	....	$2\frac{1}{4}$
	St. Louis St'd	....	6	....	5	....	$4\frac{1}{2}$	....	$3\frac{3}{4}$	....	....	3	$2\frac{3}{4}$	....	$2\frac{1}{4}$
	Premier	....	6	....	5	....	$4\frac{1}{2}$	....	$3\frac{3}{4}$	....	....	3	....	....	$2\frac{1}{4}$
Clow Mfg. Co.	Buena	....	....	6	....	$5\frac{1}{4}$	....	$4\frac{1}{4}$	....	....	$3\frac{1}{4}$	....	....	....	....
Gurney Mfg. Co	Tremont	....	....	6	....	$5\frac{1}{4}$	....	$4\frac{1}{4}$	....	....	....	....	$3\frac{1}{4}$	....	....
Holand Radiator Co.	Eclipse	....	$6\frac{1}{2}$	....	$5\frac{1}{2}$	....	$4\frac{1}{2}$	....	$3\frac{3}{4}$	....	....	3	....	....	$2\frac{1}{4}$
	Calor	6	....	....	5	....	$4\frac{1}{2}$	....	$3\frac{3}{4}$	....	....	3	....	....	$2\frac{1}{4}$
Kewanee Mfg. Co.	Kewanee	6	....	....	5	....	$4\frac{1}{2}$	....	$3\frac{3}{4}$	....	....	....	$2\frac{3}{4}$	....	$2\frac{3}{4}$
	Corinth	$6\frac{1}{2}$	....	....	$5\frac{1}{2}$	....	$4\frac{3}{4}$	....	4	....	....	....	$3\frac{1}{4}$	....	$3\frac{1}{4}$
Mott Mfg. Co.	Mercury	6	....	....	5	....	$4\frac{1}{2}$	....	$3\frac{3}{4}$	....	....	....	$2\frac{3}{4}$	....	....
	Roman	$6\frac{1}{2}$	....	....	$5\frac{1}{2}$	....	$4\frac{3}{4}$	....	4	....	....	....	$3\frac{1}{4}$	....	....
M'Lain Mfg. Co.	Seneca	$6\frac{1}{2}$	....	....	$5\frac{1}{2}$	....	$4\frac{3}{4}$	....	....	$3\frac{3}{4}$	....	....	$3\frac{1}{4}$	....	....
National Rad. Co.	Solus	6	....	....	5	....	$4\frac{1}{2}$	....	....	....	$3\frac{1}{4}$	....	$2\frac{3}{4}$	....	....
Rumsey Mfg. Co.	Niagara	....	....	....	$6\frac{1}{2}$	....	$5\frac{1}{2}$	$4\frac{1}{2}$	$3\frac{3}{4}$	....	....	$3\frac{1}{2}$	....	....	....
	Ringen	$7\frac{1}{6}$	....	6	....	5	....	4	....	....	....	3	....	....	....

Reading Rad. Co.	Tricol	....	6	....	5	....	$4\frac{1}{2}$	....	$3\frac{3}{4}$	....	....	3	....	....	$2\frac{1}{4}$
Reliance Heater Co.	Sun	6	....	....	5	....	$4\frac{1}{2}$	....	$3\frac{3}{4}$	....	$3\frac{1}{4}$	....	$2\frac{3}{4}$	....	....
Shirley Rad. Co.	Shirley	....	$6\frac{1}{2}$	....	$5\frac{1}{2}$	....	$4\frac{1}{2}$	....	$3\frac{3}{4}$	....	....	....	$2\frac{3}{4}$	....	....
South Park Foundry	Bon Ton	....	....	....	$6\frac{1}{2}$	....	....	....	....	....	....	$3\frac{1}{3}$	....	....	....
Smith, J. B. Co.	Union O. B.	....	....	....	5	$4\frac{1}{2}$	....	$3\frac{3}{4}$	....	$3\frac{1}{4}$	....	$2\frac{3}{4}$	....	....	$2\frac{1}{4}$
	Sovereign Union	....	....	....	6	....	5	....	....	4	....	....	....	....	....
	Princess Union	8	....	....	$6\frac{1}{2}$	....	$5\frac{1}{2}$	....	....	$4\frac{1}{2}$	....	....	....	$3\frac{1}{2}$	....
	Royal Union	....	6	....	5	....	4	....	....	3	....	....	....	....	2
	Imperial Union	8	....	....	$6\frac{1}{2}$	....	$5\frac{1}{2}$	....	....	$4\frac{1}{2}$	....	....	....	$3\frac{1}{2}$	....
	New Royal	....	6	....	5	....	4	....	....	3	....	....	....	....	2
	Champion	8	....	....	$6\frac{1}{2}$	....	$5\frac{1}{2}$	....	....	$4\frac{1}{2}$	....	....	....	$3\frac{1}{2}$	....
U. S. Rad. Co.	Triton	....	6	....	5	....	$4\frac{1}{2}$	....	$3\frac{3}{4}$	....	3	....	$2\frac{3}{4}$	....	$2\frac{1}{4}$
U. S. Heater Co.	Florentine	....	6	....	5	....	$4\frac{1}{2}$	....	$3\frac{3}{4}$	....	....	3	....	....	$2\frac{1}{4}$
	Puritan	....	6	....	5	....	$4\frac{1}{2}$	....	$3\frac{3}{4}$	....	....	3	....	....	$2\frac{1}{4}$

HEATING SURFACE IN PIPE RADIATORS.

To find the square feet of heating surface in pipe radiators, multiply the total length of pipe in the radiator by the following multiples:

$\frac{3}{4}$ inch pipe, multiply by .274	$1\frac{1}{2}$ inch pipe, multiply by .497
1 " " " " .344	2 " " " " .621
$1\frac{1}{4}$ " " " " .434	$2\frac{1}{2}$ " " " " .916

Tables of Radiation.

HEATING SURFACE OF RADIATORS.

Square feet of heating surface per section of four-column radiators.

Height in inches		45	44	38	33	32	28	26	23	22	20	18	16	14
Manufacturer.	Name of Radiator.	Square Feet of Heating Surface per Section.												
American Radiator Co.	Buffalo St'd	....	9	8	....	$6\frac{2}{3}$	....	$5\frac{1}{3}$	....	4	$3\frac{1}{2}$	3	....	....
	National	....	....	8	....	$6\frac{2}{3}$	....	$5\frac{1}{3}$	$4\frac{2}{3}$	....	4	....	....	....
	Peerless	....	....	8	....	$6\frac{2}{3}$	....	$5\frac{1}{3}$	$4\frac{2}{3}$	....	4	....	....	....
	St. Louis St'd ornamental	....	9	8	....	$6\frac{2}{3}$	....	$5\frac{1}{3}$	....	4	$3\frac{1}{2}$	3	....	....
	do ....plain	....	9	8	....	$6\frac{2}{3}$	....	....	....	....	....	....	....	....
Clow Mfg. Co.	Buena	....	$9\frac{2}{3}$	8	....	$6\frac{2}{3}$	....	$5\frac{1}{3}$	....	....	4	....	....	....
Holland Rad. Co.	Calor	9	....	8	....	$6\frac{2}{3}$	....	$5\frac{1}{3}$	....	4	....	3	....	....
M'Lain Mfg. Co.	Seneca	$8\frac{1}{3}$	....	7	$5\frac{2}{3}$	....	....	$4\frac{1}{3}$	....	....	$3\frac{1}{2}$	$3\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$
National Rad. Co.	Solus 5 column	....	....	8	7	....	6	....	....	5	....	....	....	....
U. S. Rad. Co.	Triton	....	$9\frac{1}{4}$	8	....	7	....	$5\frac{1}{3}$	$4\frac{1}{2}$	....	4	$3\frac{1}{2}$	....	....

Square feet of heating surface per section of flue and window radiators.

Height in inches		38	33	32	28	26	23	22	20	18	16	15	14	13
Manufacturer.	Name of Radiator.	Square Feet of Heating Surface per Section.												
American Radiator Company.	Aetna Flue	....	....	....	....	....	....	....	6	$5\frac{1}{3}$	$4\frac{2}{3}$	....	4	$3\frac{2}{3}$
	Italian Flue	7	....	$5\frac{3}{4}$	....	$4\frac{1}{2}$	....	....	$3\frac{1}{4}$	....	....	....	....	....
	St. Louis	....	....	....	....	....	....	....	....	....	....	3	....	....
	Zenith Window	....	....	....	....	....	....	....	6	$5\frac{1}{3}$	$4\frac{2}{3}$	....	4	....
	Zenith Flue	7	6	....	5	....	4	....	....	....	....	....	....	....
Clow Mfg. Co.	Buena	....	....	....	....	....	....	....	6	$5\frac{1}{3}$	$4\frac{2}{3}$	....	4	....
Holland Rad. Co	Unique	....	....	....	....	....	....	....	6	$5\frac{1}{3}$	$4\frac{2}{3}$	....	4	....
Kewanee Mfg. Co	Federal	....	....	....	....	....	....	....	6	$5\frac{1}{3}$	$4\frac{2}{3}$	....	4	4
Mott Mfg. Co	Utility	....	....	....	....	7	....	6	....	5	....	....	4	4
National Rad. Co.	Solus	....	....	....	....	....	....	....	5	4	....	....	3	....
South Park Foundry Co.	Settee	....	....	....	....	....	....	....	....	....	....	$4\frac{1}{3}$	....	....
U. S. Rad. Co	Triton	....	....	....	....	....	....	....	....	....	4	$3\frac{1}{2}$	....	3

COLONIAL WALL RADIATORS.

Extra-large size 29 inches long, $13\frac{1}{4}$ inches wide, $2\frac{5}{8}$ inches thick, contains 9 square feet of heating surface.
Standard size 23 inches long, $13\frac{1}{4}$ inches wide, $2\frac{5}{8}$ inches thick, contains 7 square feet of heating surface.
Small size, $16\frac{3}{4}$ inches long, $13\frac{1}{4}$ inches wide, $2\frac{5}{8}$ inches thick, contains 5 square feet of heating surface.

Tables of Radiation.

MEASUREMENTS OF VARIOUS RADIATORS.

Width in inches. Legs.	Width in inches. Body.	Name of Radiator.	Length Occupied in Stack by Each Section in Inches.
12½	12½	Aetna Flue	3
12	12	Areal, box base	3
8⅛	7⅜	Astro, two-column	3
7¾	7⅛	Acme, two-column	2½
12	10⅜	Bon Ton, three-column	2⅛
5½	5⅛	Buffalo, single-column	2½
8½	7¼	Buffalo, two-column	2½
9⅛	8⅞	Buffalo, three-column	2½
12	11⅝	Buffalo, four-column	2½
9	8⅝	Breman, two-column	2½
7¼	7¼	Buena, two-column	2½
9¾	9¾	Buena, three-column	2½
8½	8½	Buena, four-column	4⅛
12¾	12¾	Buena, window	2½
5½	5	Calor, single-column	2½
8⅜	7½	Calor, two-column	2½
9½	9	Calor, three-column	2½
12½	12	Calor, four-column	2½
11	9	Champion Union, three-column	3¼
7¼	5	Crown, two-column	3
8¼	7¼	Chautauqua, two-column	2½
10¼	9½	Corinth, three-column	2½
7¼	5	Coronet, two-column	3
6⅜	6⅜	Ducol, two-column	2½
7¾	7¼	Duet, two-column	2½
7	5	Diadem, two-column	3
9	8¾	Eclipse, three-column	2½
8⅝	7¼	Excelsior, two-column	2
13	12¼	Federal, window	
9¼	7¼	Favorite, two-column	2⅗
10	9⅛	Florentine, three-column	2½

MEASUREMENTS OF VARIOUS RADIATORS. — *Continued.*

Width in Inches. Legs.	Width in Inches. Body.	Name of Radiator.	Length Occupied in Stack by Each Section in Inches.
$8\frac{1}{2}$	$7\frac{3}{8}$	Ideal, two-column	$2\frac{1}{2}$
$8\frac{1}{2}$	$8\frac{1}{2}$	Italian Flue	3
11	9	Imperial Union, three-column	$3\frac{1}{4}$
$9\frac{7}{8}$	$9\frac{3}{4}$	Kewanee, three-column	$2\frac{1}{2}$
$5\frac{1}{2}$	$4\frac{1}{4}$	National, single-column	$2\frac{1}{2}$
$8\frac{1}{2}$	$7\frac{3}{8}$	National, two-column	$2\frac{1}{2}$
$11\frac{1}{2}$	$10\frac{1}{2}$	National, four-column	$2\frac{1}{2}$
6	6	Niagara Junior	3
7	7	Niagara, two-column	$2\frac{1}{2}$
$10\frac{1}{2}$	$10\frac{1}{2}$	Niagara, three-column	3
8	8	New Royal, three-column	3
$5\frac{1}{2}$	$4\frac{1}{2}$	Peerless, single-column	$2\frac{1}{2}$
$8\frac{1}{2}$	$7\frac{3}{8}$	Peerless, two-column	$2\frac{1}{2}$
$10\frac{1}{4}$	10	Peerless, three-column	$2\frac{1}{2}$
$11\frac{1}{4}$	$10\frac{1}{2}$	Peerless, four-column	$2\frac{3}{4}$
$9\frac{1}{4}$	$7\frac{1}{4}$	Perfection, two-column	$2\frac{1}{2}$
$10\frac{3}{4}$	9	Princess Union, three-column	$3\frac{1}{4}$
10	$9\frac{1}{8}$	Puritan	$2\frac{1}{2}$
$8\frac{3}{8}$	$7\frac{1}{2}$	Rising Sun, two-column	$2\frac{1}{2}$
$10\frac{1}{4}$	10	Rococo, three-column	$2\frac{1}{2}$
$10\frac{1}{2}$	10	Ringen, two-column	$2\frac{3}{4}$
$5\frac{3}{4}$	$5\frac{1}{4}$	Roman, single-column	2
$8\frac{1}{4}$	$7\frac{3}{4}$	Roman, two-column	$2\frac{1}{2}$
$10\frac{1}{4}$	$9\frac{1}{2}$	Roman, three-column	$2\frac{1}{2}$
$8\frac{1}{2}$	$7\frac{1}{4}$	Reliance, two-column	$2\frac{1}{2}$
11	8	Royal Union, three-column	3
$11\frac{1}{4}$	$11\frac{1}{4}$	Star, two-column	$2\frac{1}{2}$
$8\frac{1}{2}$	$7\frac{5}{8}$	Solar, two-column	$2\frac{1}{2}$
8	$7\frac{1}{4}$	Solus, two-column	$2\frac{1}{2}$
$9\frac{3}{4}$	$8\frac{3}{4}$	Solus, three-column	$2\frac{1}{2}$

MEASUREMENTS OF VARIOUS RADIATORS. — *Continued.*

Width in Inches. Legs.	Width in Inches. Body.	Name of Radiator.	Length Occupied in Stack by Each Section in Inches.
$12\frac{1}{2}$	$11\frac{3}{4}$	Solus, five-column	$2\frac{1}{2}$
$8\frac{1}{4}$	$7\frac{1}{4}$	Seneca, two-column	$2\frac{1}{2}$
$10\frac{3}{4}$	$9\frac{7}{8}$	Seneca, three-column	$2\frac{1}{2}$
$11\frac{1}{2}$	11	Seneca, four-column	$2\frac{1}{2}$
$8\frac{1}{4}$	$7\frac{1}{4}$	Shirley, two-column	$2\frac{1}{2}$
$9\frac{7}{8}$	$9\frac{1}{8}$	Shirley, three-column	$2\frac{1}{2}$
$6\frac{1}{8}$	$5\frac{1}{2}$	St. Louis, single-column	$2\frac{1}{2}$
$8\frac{1}{2}$	7	St. Louis, two-column	$2\frac{1}{2}$
$9\frac{1}{2}$	9	St. Louis, three-column	$2\frac{1}{2}$
$12\frac{3}{4}$	$11\frac{3}{4}$	St. Louis, four-column	$2\frac{1}{2}$
$11\frac{3}{4}$	$11\frac{5}{10}$	St. Louis, window	$2\frac{1}{2}$
7	7	Scepter, two-column	$2\frac{3}{8}$
$8\frac{5}{8}$	$8\frac{5}{8}$	Sovereign Union, three-column	$2\frac{3}{4}$
12	$11\frac{3}{4}$	Solus, window	$2\frac{1}{2}$
$5\frac{1}{4}$	$4\frac{1}{2}$	Triton, single-column	$2\frac{1}{2}$
$8\frac{1}{4}$	$7\frac{1}{4}$	Triton, two-column	$2\frac{1}{2}$
$10\frac{1}{8}$	$9\frac{1}{8}$	Triton, three-column	$2\frac{1}{2}$
$13\frac{3}{4}$	$12\frac{3}{4}$	Triton, four-column	$2\frac{1}{2}$
$12\frac{3}{4}$	$12\frac{3}{4}$	Triton, window	3
7	7	Tiara, two-column	$2\frac{3}{8}$
$9\frac{1}{8}$	$9\frac{3}{4}$	Tricol, three-column	$2\frac{1}{2}$
11	8	Union O. B., three-column	3
$12\frac{3}{4}$	$12\frac{3}{4}$	Unique, window	$2\frac{1}{2}$
$11\frac{1}{4}$	$11\frac{1}{4}$	Utility, window	$2\frac{3}{4}$
$8\frac{1}{2}$	8	Verona, two-column	$2\frac{1}{2}$
9	$8\frac{1}{2}$	Webster Sheet Metal Radiator	$2\frac{1}{2}$
14	14	Settee, window	$2\frac{7}{8}$
$9\frac{1}{2}$	$8\frac{1}{2}$	Zenith, flue	$2\frac{5}{8}$
6	$5\frac{1}{2}$	Zenith, narrow	$2\frac{3}{8}$
$12\frac{3}{4}$	$12\frac{1}{2}$	Zenith, window	$2\frac{3}{8}$

TAPPING LIST OF RADIATORS USED BY THE VARIOUS MANUFACTURERS.

Steam.

ONE-PIPE WORK.

Radiators containing 24 square feet and under	1 inch
Above 24, but not exceeding 60 feet	$1\frac{1}{4}$ inch
Above 60, but not exceeding 100 feet	$1\frac{1}{2}$ inch
Above 100 square feet	2 inch

TWO-PIPE WORK.

Radiators containing 48 square feet and under	$1 \times \frac{3}{4}$ inch
Above 48, but not exceeding 96 feet	$1\frac{1}{4} \times 1\frac{1}{4}$ inch
Above 96 square feet	$1\frac{1}{2} \times 1\frac{1}{4}$ inch

Hot Water.

TAPPED FOR SUPPLY AND RETURN.

Radiators containing 40 square feet and under	1 inch
Above 40, but not exceeding 72 square feet	$1\frac{1}{4}$ inch
Above 72 square feet	$1\frac{1}{2}$ inch

TABLE OF POWER OF TRANSMITTING HEAT OF VARIOUS BUILDING SUBSTANCES, COMPARED WITH EACH OTHER.

Window Glass	1.000
Oak and Walnut	.66
White Pine	.80
Pitch Pine	100
Lath and Plaster	.75 to 100
Common Brick (rough)	.200 to .250
Common Brick (whitewashed)	.200
Granite or Slate	.250
Sheet Iron	1.030 to 1.110

Various Computation Tables.

Cubical Contents of Rooms. — The following tables (used by permission of the International Heater Co.) will be found of great convenience in calculating the cubical contents of various rooms. The variety of combinations given is applicable to nearly every condition met in ordinary practice.

For convenience in making calculations it is suggested that dimensions under 3 inches be dropped; over 3 inches and under 9 inches be extended as 6 inches and over 9 inches as the next higher number in feet.

Example: The actual measurements of a room are 9′ 2″ × 12′ 10″ with 8′ 10″ ceiling. To use the table consider the room 9 × 13 × 9.

Again, where in the larger numbers variations of ½ foot are omitted, a little experience will indicate that the tables are readily adapted to such conditions.

Example: The actual measurements of a room are 11½′ × 13½′ × 9½′, the actual cubic contents are therefore 1475 cubic feet, and it is a tedious process to arrive at this conclusion by ordinary methods.

To use the table increase the first number by 6 inches and diminish the second by 6 inches and using the product found under 12 × 13 × 9½ we have 1482 which is as close approximation as is required in practice.

Or the dimensions 11 × 14 could have been used with a variation from the true result of only 12 cubic feet, too small an error to affect results.

CUBICAL CONTENTS OF ROOMS.

Floor Area.	Having Ceilings of the Following Heights.							
	8 ft.	8½ ft.	9 ft.	9½ ft.	10 ft.	10½ ft.	11 ft.	12 ft.
3 × 3	72	77	81	85	90	95	99	108
3 × 3½	84	89	95	99	105	110	115	126
3 × 4	96	102	108	114	120	126	132	144
3 × 4½	108	115	122	128	135	142	148	162
3 × 5	120	128	135	142	150	158	165	180
3 × 5½	132	140	149	156	165	173	181	198
3 × 6	144	153	162	171	180	189	198	216
3½ × 3½	98	104	110	116	123	129	134	147
3½ × 4	112	119	126	133	140	147	154	168
3½ × 4½	126	134	142	149	158	165	173	189
3½ × 5	140	149	158	166	175	184	192	210
3½ × 5½	154	164	173	182	193	202	211	231
3½ × 6	168	179	189	199	210	221	231	252
3½ × 6½	182	193	205	216	228	239	250	273
3½ × 7	196	208	221	232	245	257	269	294
4 × 4	128	136	144	152	160	168	176	192
4 × 4½	144	153	162	171	180	189	198	216
4 × 5	160	170	180	190	200	210	220	240
4 × 5½	176	187	198	209	220	231	422	264
4 × 6	192	204	216	228	240	252	264	288
4 × 6½	208	221	234	247	260	273	286	312
4 × 7	224	238	252	266	280	294	308	336
4 × 7½	240	255	270	285	300	315	330	360
4 × 8	256	272	288	304	320	336	352	384
4½ × 4½	162	172	182	192	203	213	222	243
4½ × 5	180	191	203	213	225	236	247	270
4½ × 5½	198	210	223	235	248	260	272	297
4¼ × 6	216	230	243	256	270	284	297	324
4½ × 6½	234	249	263	277	293	307	321	351
4½ × 7	252	268	284	299	315	331	346	378
4½ × 7½	270	287	304	320	338	354	371	405
4½ × 8	288	306	324	342	360	378	396	432
4½ × 8½	306	325	344	363	383	402	420	459
4½ × 9	324	345	365	384	405	425	445	486
5 × 5	200	212	225	237	250	263	275	300
5 × 5½	220	234	248	261	275	289	302	330
5 × 6	240	255	270	285	300	315	330	360
5 × 6½	260	276	293	308	325	341	357	390
5 × 7	280	297	315	332	350	368	385	420
5 × 7½	300	319	338	358	375	394	412	450
5 × 8	320	340	360	380	400	420	440	480
5 × 8½	340	361	383	403	425	446	467	510
5 × 9	360	382	405	427	450	473	495	540
5 × 9½	380	404	428	451	475	499	522	570
5 × 10	400	425	450	475	500	525	550	600
5½ × 5½	242	257	272	287	303	318	332	363
5½ × 6	264	281	297	313	330	347	363	396
5½ × 6½	286	304	322	339	358	375	393	429
5½ × 7	308	327	347	365	385	404	423	462
5½ × 7½	330	351	371	391	413	433	453	495
5½ × 8	352	374	396	418	440	462	484	528
5½ × 8½	374	397	421	444	468	491	514	561
5½ × 9	396	421	446	470	495	520	544	594
5½ × 9½	418	444	470	496	523	549	574	627

CUBICAL CONTENTS OF ROOMS. — *Continued.*

Floor Area.	Having Ceilings of the Following Heights.							
	8 ft.	8½ ft.	9 ft.	9½ ft.	10 ft.	10½ ft.	11 ft.	12 ft.
5½ × 10	440	468	495	522	550	578	605	660
5½ × 10½	462	491	520	548	578	606	635	693
5½ × 11	484	514	545	574	605	635	665	726
6 × 6	288	306	324	342	360	378	396	432
6½ × 6½	312	332	351	370	390	410	429	468
6 × 7	336	357	378	399	420	441	462	504
6 × 7½	360	383	405	427	450	473	495	540
6 × 8	384	408	432	456	480	504	528	576
6 × 8½	408	434	459	484	510	536	561	612
6 × 9	432	459	486	513	540	567	594	648
6 × 9½	456	485	513	541	570	599	627	684
6 × 10	480	510	540	570	600	630	660	720
6 × 10½	504	536	567	598	630	662	693	756
6 × 11	528	561	594	627	660	693	726	792
6 × 11½	552	587	621	655	690	725	759	828
6 × 12	576	612	648	684	720	756	792	864
6½ × 6½	338	359	380	401	423	444	464	507
6½ × 7	364	387	410	432	455	478	500	546
6½ × 7½	390	414	439	463	488	512	536	585
6½ × 8	416	442	468	494	520	546	572	624
6½ × 8½	442	470	497	524	553	580	607	663
6½ × 9	468	497	527	555	585	615	643	702
6½ × 9½	494	525	556	586	618	648	679	741
6½ × 10	520	553	585	617	650	683	715	780
6½ × 10½	546	580	614	648	683	717	750	819
6½ × 11	572	608	644	679	715	751	786	858
6½ × 11½	598	635	673	710	748	785	822	897
6½ × 12	624	663	702	741	780	819	858	936
6½ × 12½	650	691	731	771	813	853	893	975
6½ × 13	676	718	761	802	845	887	929	1014
7 × 7	392	417	441	465	490	515	539	588
7 × 7½	420	446	473	498	525	551	577	630
7 × 8	448	476	504	532	560	588	616	672
7 × 8½	476	506	536	565	595	625	654	714
7 × 9	504	336	567	598	630	662	693	756
7 × 9½	532	565	599	631	665	698	731	798
7 × 10	560	595	630	665	700	735	770	840
7 × 10½	588	625	662	698	735	772	808	882
7 × 11	616	655	693	731	770	809	847	924
7 × 11½	644	684	725	764	805	845	885	966
7 × 12	672	714	756	798	840	882	924	1008
7 × 12½	700	744	788	831	875	919	962	1050
7 × 13	728	774	819	864	910	956	1001	1092
7 × 13½	756	803	851	897	945	992	1039	1134
7 × 14	784	833	882	931	980	1029	1078	1176
7½ × 7½	450	478	506	534	563	591	618	675
7½ × 8	480	510	540	570	600	630	660	720
7½ × 8½	510	542	574	605	638	669	701	765
7½ × 9	540	574	608	641	675	709	742	810
7½ × 9½	570	606	641	676	713	748	783	855
7½ × 10	600	638	675	712	750	788	825	900
7½ × 10½	630	669	709	748	788	827	866	945
7½ × 11	660	701	743	783	825	866	907	990
7½ × 11½	690	733	776	819	863	906	948	1035

CUBICAL CONTENTS OF ROOMS.—*Continued.*

Floor Area.	Having Ceilings of the Following Heights.							
	8 ft.	8½ ft.	9 ft.	9½ ft.	10 ft.	10½ ft.	11 ft.	12 ft.
7½×12	720	765	810	855	900	945	990	1080
7½×12½	750	797	844	890	938	984	1031	1125
7½×13	780	829	878	926	975	1024	1072	1170
7½×13½	810	861	911	961	1013	1063	1113	1215
7½×14	840	893	945	997	1050	1103	1155	1260
7½×14½	870	924	979	1033	1088	1142	1196	1305
7½×15	900	956	1013	1068	1125	1181	1237	1350
8 × 8	512	544	576	608	640	672	704	768
8 × 8½	544	578	612	646	680	714	748	816
8 × 9	576	612	648	684	720	756	792	864
8 × 9½	608	646	684	722	760	798	836	912
8 ×10	640	680	720	760	800	840	880	960
8 ×10½	672	714	756	798	840	882	924	·1008
8 ×11	704	748	792	836	880	924	968	1056
8 ×11½	736	782	828	874	920	966	1012	1104
8 ×12	768	816	864	912	960	1008	1056	1152
8 ×12½	800	850	900	950	1000	1050	1100	1200
8 ×13	832	884	936	988	1040	1092	1144	1248
8 ×13½	864	918	972	1026	1080	1134	1188	1296
8 ×14	896	952	1008	1064	1120	1176	1232	1344
8 ×14½	928	986	1044	1102	1160	1218	1276	1392
8 ×15	960	1020	1080	1140	1200	1260	1320	1440
8 ×15½	992	1054	1116	1178	1240	1302	1364	1488
8 ×16	1024	1088	1152	1216	1280	1344	1408	1536
8½× 8½	578	614	650	686	723	759	794	867
8½× 9	612	650	689	726	765	803	841	918
8½× 9½	646	686	727	767	808	848	888	969
8½×10	680	723	765	807	850	893	935	1020
8½×10½	714	759	803	847	893	937	981	1071
8½×11	748	795	842	888	935	982	1028	1122
8½×11½	782	831	880	928	978	1026	1075	1173
8½×12	816	867	918	969	1020	1071	1122	1224
8½×12½	850	903	956	1009	1063	1116	1168	1275
8½×13	884	939	995	1049	1105	1160	1215	1326
8½×13½	918	975	1033	1090	1148	1205	1262	1377
8½×14	952	1012	1071	1130	1190	1250	1309	1428
8½×14½	986	1048	1109	1170	1233	1294	1355	1479
8½×15	1020	1084	1148	1211	1275	1339	1402	1530
8½×15½	1054	1120	1186	1251	1318	1383	1449	1581
8½×16	1088	1156	1224	1292	1360	1428	1496	1632
8½×16½	1122	1192	1262	1332	1403	1473	1542	1683
8½×17	1156	1228	1301	1372	1445	1517	1589	1734
9 × 9	648	689	729	769	810	851	891	972
9 × 9½	684	727	770	812	855	898	940	1026
9 ×10	720	765	810	855	900	945	990	1080
9 ×10½	756	803	851	897	945	992	1039	1134
9 ×11	792	842	891	940	990	1040	1089	1188
9 ×11½	828	880	932	982	1035	1087	1138	1242
9 ×12	864	918	972	1026	1080	1134	1188	1296
9 ×12½	900	956	1013	1068	1125	1181	1237	1350
9 ×13	936	995	1053	1111	1170	1229	1287	1404
9 ×13½	972	1033	1094	1154	1215	1276	1336	1458
9 ×14	1008	1071	1134	1197	1260	1323	1386	1512
9 ×14½	1044	1109	1175	1239	1305	1370	1435	1566

CUBICAL CONTENTS OF ROOMS.—*Continued.*

Floor Area.	Having Ceilings of the Following Heights.							
	8 ft.	8½ ft.	9 ft.	9½ ft.	10 ft.	10½ ft.	11 ft.	12 ft.
9 ×15	1080	1148	1215	1282	1350	1418	1485	1620
9 ×15½	1116	1186	1256	1325	1395	1465	1534	1674
9 ×16	1152	1224	1296	1368	1440	1512	1584	1728
9 ×16½	1188	1262	1337	1410	1485	1559	1633	1782
9 ×17	1224	1301	1377	1453	1530	1607	1683	1836
9 ×17½	1260	1339	1418	1496	1575	1654	1732	1890
9 ×18	1296	1377	1458	1539	1620	1701	1782	1944
9½× 9½	722	767	812	857	903	948	992	1083
9½×10	760	808	855	902	950	998	1045	1140
9½×10½	798	848	898	947	998	1047	1097	1197
9½×11	836	888	940	992	1045	1097	1149	1254
9½×11½	874	929	983	1038	1093	1147	1201	1311
9½×12	912	969	1026	1083	1140	1197	1254	1368
9½×12½	950	1009	1069	1128	1188	1247	1306	1425
9½×13	988	1050	1111	1173	1235	1297	1358	1482
9½×13½	1026	1090	1154	1218	1283	1347	1410	1539
9½×14	1064	1131	1197	1263	1330	1397	1463	1596
9½×14½	1102	1171	1240	1308	1378	1446	1515	1653
9½×15	1140	1211	1282	1353	1425	1496	1567	1710
9½×15½	1178	1252	1325	1398	1473	1546	1619	1767
9½×16	1216	1292	1368	1444	1520	1596	1672	1824
9½×16½	1254	1332	1411	1489	1568	1646	1724	1881
9½×17	1292	1373	1453	1534	1615	1696	1776	1938
9½×17½	1330	1413	1496	1579	1663	1746	1828	1995
9½×18	1368	1454	1539	1624	1710	1796	1881	2052
9½×18½	1406	1494	1582	1669	1758	1845	1933	2109
9½×19	1444	1534	1625	1714	1805	1895	1895	2166
10 ×10	800	850	900	950	1000	1050	1100	1200
10 ×10½	840	893	945	997	1050	1103	1155	1260
10 ×11	880	935	990	1045	1100	1155	1210	1320
10 ×11½	920	978	1035	1092	1150	1208	1265	1380
10 ×12	960	1020	1080	1140	1200	1260	1320	1440
10 ×12½	1000	1063	1125	1187	1250	1313	1375	1500
10 ×13	1040	1105	1170	1235	1300	1365	1430	1560
10 ×13½	1080	1148	1215	1282	1350	1418	1485	1620
10 ×14	1120	1190	1260	1330	1400	1470	1540	1680
10 ×14½	1160	1233	1305	1377	1450	1523	1595	1740
10 ×15	1200	1275	1350	1425	1500	1575	1650	1800
10 ×15½	1240	1318	1395	1472	1550	1628	1705	1860
10 ×16	1280	1360	1440	1520	1600	1680	1760	1920
10 ×16½	1320	1403	1485	1567	1650	1733	1815	1980
10 ×17	1360	1445	1530	1615	1700	1785	1870	2040
10 ×17½	1400	1488	1575	1662	1750	1838	1925	2100
10 ×18	1440	1530	1620	1710	1800	1890	1980	2160
10 ×18½	1480	1573	1665	1757	1850	1943	2035	2220
10 ×19	1520	1615	1710	1805	1900	1995	2090	2280
10 ×19½	1560	1658	1755	1852	1950	2048	2145	2340
10 ×20	1600	1700	1800	1900	2000	2100	2200	2400
11 ×11	968	1029	1089	1149	1210	1271	1331	1452
11 ×12	1056	1122	1188	1254	1320	1386	1452	1584
11 ×13	1144	1216	1287	1358	1430	1502	1573	1716
11 ×14	1232	1309	1386	1463	1540	1617	1694	1848
11 ×15	1320	1403	1485	1567	1650	1733	1815	1980
11 ×16	1408	1496	1584	1672	1760	1848	1936	2112

CUBICAL CONTENTS OF ROOMS.—*Continued.*

Floor Area.	Having Ceilings of the Following Heights.							
	8 ft.	$8\frac{1}{2}$ ft.	9 ft.	$9\frac{1}{2}$ ft.	10 ft.	$10\frac{1}{2}$ ft.	11 ft.	12 ft.
11×17	1496	1590	1683	1776	1870	1964	2057	2244
11×18	1584	1683	1782	1881	1980	2079	2178	2376
11×19	1672	1777	1881	1986	2090	2195	2299	2508
11×20	1760	1870	1980	2090	2200	2310	2420	2640
11×21	1848	1964	2079	2194	2310	2426	2541	2772
11×22	1936	2057	2178	2299	2420	2541	2662	2904
12×12	1152	1224	1296	1368	1440	1512	1584	1728
12×13	1248	1326	1404	1482	1560	1638	1716	1872
12×14	1344	1428	1512	1596	1680	1764	1848	2016
12×15	1440	1530	1620	1710	1800	1890	1980	2160
12×16	1536	1632	1728	1824	1920	2016	2112	2304
12×17	1632	1734	1836	1938	2040	2142	2244	2448
12×18	1728	1836	1944	2052	2160	2268	2376	2592
12×19	1824	1938	2052	2166	2280	2394	2508	2736
12×20	1920	2040	2160	2280	2400	2520	2640	2880
12×21	2016	2142	2268	2394	2520	2646	2772	3024
12×22	2112	2244	2376	2508	2640	2772	2904	3168
12×23	2208	2346	2484	2622	2760	2898	3036	3312
12×24	2304	2448	2592	2736	2880	3024	3168	3456
13×13	1352	1437	1521	1605	1690	1775	1859	2028
13×14	1456	1547	1638	1729	1820	1911	2002	2184
13×15	1560	1658	1755	1852	1950	2048	2145	2340
13×16	1664	1768	1872	1976	2080	2184	2288	2496
13×17	1768	1879	1989	2099	2210	2321	2431	2652
13×18	1872	1989	2106	2223	2340	2457	2574	2808
13×19	1976	2100	2223	2346	2470	2594	2717	2964
13×20	2080	2210	2340	2470	2600	2730	2860	3120
13×21	2184	2321	2457	2593	2730	2867	3003	3276
13×22	2288	2431	2574	2717	2860	3003	3146	3432
13×23	2392	2542	2691	2840	2990	3140	3289	3588
13×24	2496	2652	2808	2964	3120	3276	3432	3744
13×25	2600	2763	2925	3087	3250	3413	3575	3900
13×26	2704	2873	3042	3211	3380	3549	3718	4056
14×14	1568	1666	1764	1862	1960	2058	2156	2352
14×15	1680	1785	1890	1995	2100	2205	2310	2520
14×16	1792	1904	2016	2128	2240	2352	2464	2688
14×17	1904	2023	2142	2261	2380	2499	2618	2856
14×18	2016	2142	2268	2394	2520	2646	2772	3024
14×19	2128	2261	2394	2527	2660	2793	2926	3192
14×20	2240	2380	2520	2660	2800	2940	3080	3360
14×21	2352	2499	2646	2793	2940	3087	3234	3528
14×22	2464	2618	2772	2926	3080	3234	3388	3696
14×23	2576	2737	2898	3059	3220	3381	3542	3864
14×24	2688	2856	3024	3192	3360	3528	3696	4032
14×25	2800	2975	3150	3325	3500	3675	3850	4200
14×26	2912	3094	3276	3458	3640	3822	4004	4368
14×27	3024	3213	3402	3591	3780	3969	4158	4536
14×28	3136	3332	3528	3724	3920	4116	4312	4704
15×15	1800	1913	2025	2137	2250	2363	2475	2700
15×16	1920	2040	2160	2280	2400	2520	2640	2880
15×17	2040	2168	2295	2422	2550	2678	2805	3060
15×18	2160	2295	2430	2565	2700	2835	2970	3240
15×19	2280	2423	2565	2707	2850	2993	3135	3420
15×20	2400	2550	2700	2850	3000	3150	3300	3600

CUBICAL CONTENTS OF ROOMS.—*Continued.*

Floor Area.	Having Ceilings of the Following Heights.							
	8 ft.	8½ ft.	9 ft.	9½ ft.	10 ft.	10½ ft.	11 ft.	12 ft.
15×21	2520	2678	2835	2992	3150	3308	3465	3780
15×22	2640	2805	2970	3135	3300	3465	3630	3960
15×23	2760	2933	3105	3277	3450	3623	3795	4140
15×24	2880	3060	3240	3420	3600	3780	3960	4320
15×25	3000	3188	3375	3562	3750	3938	4125	4500
15×26	3120	3315	3510	3705	3900	4095	4290	4680
15×27	3240	3443	3645	3847	4050	4253	4455	4860
15×28	3360	3570	3780	3990	4200	4410	4620	5040
15×29	3480	3698	3915	4132	4350	4568	4785	5220
15×30	3600	3825	4050	4275	4500	4725	4950	5400
16×16	2048	2176	2304	2432	2560	2688	2816	3072
16×17	2176	2312	2448	2584	2720	2856	2992	3264
16×18	2304	2448	2592	2736	2880	3024	3168	3456
16×19	2432	2584	2736	2888	3040	3192	3344	3648
16×20	2560	2720	2880	3040	3200	3360	3520	3840
16×21	2688	2856	3024	3192	3360	3528	3696	4032
16×22	2816	2992	3168	3344	3520	3696	3872	4224
16×23	2944	3128	3312	3496	3680	3864	4048	4416
16×24	3072	3264	3456	3648	3840	4032	4224	4608
16×25	3200	3400	3600	3800	4000	4200	4400	4800
16×26	3328	3536	3744	3952	4160	4368	4576	4992
16×27	3456	3672	3888	4104	4320	4336	4752	5184
16×28	3584	3808	4032	4256	4480	4704	4928	5376
16×29	3712	3944	4176	4408	4640	4872	5104	5568
16×30	3840	4080	4320	4560	4800	5040	5280	5760
16×31	3968	4216	4464	4712	4960	5208	5456	5952
16×32	4096	4352	4608	4864	5120	5376	5632	6144
18×18	2592	2754	2916	3078	3240	3402	3564	3888
18×20	2880	3060	3240	3420	3600	3780	3960	4320
18×22	3168	3366	3564	3762	3960	4158	4356	4752
18×24	3456	3672	3888	4104	4320	4536	4752	5184
18×26	3744	3978	4212	4446	4680	4914	5148	5616
18×28	4032	4284	4536	4788	5040	5292	5544	6048
18×30	4320	4590	4860	5130	5400	5670	5940	6480
18×32	4608	4896	5184	5472	5760	6048	6336	6912
18×34	4896	5202	5508	5814	6120	6426	6732	7344
18×36	5184	5508	5832	6156	6480	6804	7126	7776
20×20	3200	3400	3600	3800	4000	4200	4400	4800
20×22	3520	3740	3960	4180	4400	4620	4840	5280
20×24	3840	4080	4320	4560	4800	5040	5280	5760
20×26	4160	4420	4680	4940	5200	5460	5720	6240
20×28	4480	4760	5040	5320	5600	5880	6160	6720
20×30	4800	5100	5400	5700	6000	6300	6600	7200
20×32	5120	5440	5760	6080	6400	6720	7040	7680
20×34	5440	5780	6120	6460	6800	7140	7480	8160
20×36	5760	6120	6480	6840	7200	7560	7920	8640
20×38	6080	6460	6840	7220	7600	7980	8360	9120
20×40	6400	6800	7200	7600	8000	8400	8800	9600

NUMBER OF SQUARE INCHES OF FLUE AREA REQUIRED PER 1,000 CUBIC FEET OF CONTENTS FOR GIVEN VELOCITY AND AIR CHANGE.

No. *Minutes* to Change Air.	Velocity of Air in Flue in Feet per Minute.												
	300	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**	**1200**	**1300**	**1400**	**1500**
4	120.	90.	72.	60.	51.6	45.	40.	36.	32.2	30.	27.6	25.6	21.4
5	96.	72.2	57.6	48.	41.1	36.1	32.	28.8	26.2	24.	22.2	20.5	19.2
6	80.	60.	48.	40.	34.3	30.	26.6	24.	21.8	20.	18.5	17.1	16.
7	68.6	51.4	41.1	34.3	29.4	25.7	22.9	20.6	18.7	17.2	15.7	14.7	13.7
8	60.	45.	36.	30.	25.8	22.5	20.	18.	16.1	15.	13.8	12.8	12.
9	53.3	40.	32.	26.6	22.9	20.	17.8	16.	14.5	13.3	12.3	11.4	10.7
10	48.	36.	28.8	24.	20.6	18.	16.	14.4	13.1	12.	11.1	10.3	9.6
11	43.6	32.2	26.2	21.8	18.7	16.1	14.5	13.1	11.9	10.9	10.1	9.5	8.7
12	40.	30.	24.	20.	17.2	15.	13.3	12.	10.9	10.	9.2	8.6	8.
13	36.9	27.7	22.2	18.5	15.7	13.8	12.3	11.1	10.1	9.2	8.5	7.9	7.4
14	34.3	25.7	20.6	17.2	14.7	12.8	11.4	10.3	9.5	8.6	7.9	7.4	6.9
15	32.	24.	19.2	16.	13.7	12.	10.7	9.6	8.7	8.	7.4	6.9	6.4
16	30.	22.5	18.	15.	12.9	11.2	10.	9.	8.2	7.5	6.9	6.4	6.
17	28.2	21.2	16.9	14.1	12.1	10.6	9.4	8.5	7.7	7.	6.5	6.1	5.6
18	26.6	20.	16.	13.3	11.5	10.	8.9	8.	7.3	6.6	6.2	5.7	5.3
19	25.3	18.9	15.2	12.6	10.8	9.5	8.4	7.6	6.9	6.3	5.8	5.4	5.1
20	24.	18.	14.4	12.	10.3	9.	8.	7.2	6.5	6.	5.5	5.1	4.8

To facilitate calculation of flue areas for different requirements in heating, ventilation and the general movement of air, the table above and that upon the two succeeding pages have been prepared. The former is to be employed when the ventilating system area of the flue is to be based upon the time required to change the air within the room and upon the permissible velocity in the flue. The latter table indicates the flue area necessary for the passage of a predetermined volume of air at stated velocity. Values for volumes below 100 or above 1,000 cubic feet may be readily determined from the latter table by reading for the multiple of the given volume, and then pointing off the requisite number of places. Thus, if a volume of 8,750 cubic feet of air is required to pass through a flue at a velocity of 900 feet per minute, the cross sectional area of that flue must be 1,400 square inches.

FLUE AREA REQUIRED FOR THE PASSAGE OF A GIVEN VOLUME OF AIR AT A GIVEN VELOCITY.

Volume in Cu. Ft. per Min.	Velocity in Feet per Minute.													
	300	**400**	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**	**1200**	**1300**	**1400**	1500	1600
100	**48**	**36**	**29**	**24**	**21**	**18**	**16**	**14**	**13**	**12**	**11**	**10**	**9.6**	**9.**
125	60	45	36	30	26	23	20	18	16	15	14	13	12.	11.3
150	72	52	43	36	31	27	24	22	20	18	16	15	14.4	13.5
175	84	63	50	42	36	32	28	25	23	21	19	18	16.8	15.8
200	**96**	**72**	**58**	**48**	**41**	**36**	**32**	**29**	**26**	**24**	**22**	**21**	**19.2**	**18.**
225	108	81	65	54	46	41	36	32	29	27	25	23	21.6	20.3
250	120	90	72	60	51	45	40	36	33	30	28	26	24.	22.5
275	132	99	79	66	57	50	44	40	36	33	30	28	26.4	24.8
300	**144**	**108**	**86**	**72**	**62**	**54**	**48**	**43**	**39**	**36**	**33**	**31**	**28.8**	**27.**
325	156	117	94	78	67	59	52	47	43	39	36	33	31.2	29.3
350	168	126	101	84	72	63	56	50	46	42	39	36	33.6	31.5
375	180	135	108	90	77	68	60	54	49	45	42	39	36.	33.8
400	**192**	**144**	**115**	**96**	**82**	**72**	**64**	**58**	**52**	**48**	**44**	**41**	**38.4**	**36.**
425	204	153	122	102	87	77	68	61	56	51	47	44	40.8	38.3
450	216	162	130	108	93	81	72	65	59	54	50	46	43.2	40.5
475	228	171	137	114	98	86	76	68	62	57	53	49	45.6	42.8
500	**240**	**180**	**144**	**120**	**103**	**90**	**80**	**72**	**65**	**60**	**55**	**51**	**48.**	**45.**
525	252	189	151	126	108	95	84	76	69	63	58	54	50.4	47.3
550	264	198	158	132	113	99	88	79	72	66	61	57	52.8	49.5
575	276	207	166	138	118	104	92	83	75	69	64	59	55.2	51.8
600	**288**	**216**	**173**	**144**	**123**	**108**	**96**	**86**	**79**	**72**	**66**	**62**	**57.6**	**54.**
625	300	225	180	150	129	113	100	90	82	75	69	64	60.	56.3
650	312	234	187	156	134	117	104	94	85	78	72	67	62.4	58.5
675	324	243	194	162	139	122	108	97	88	81	75	69	64.8	60.8
700	**336**	**252**	**202**	**168**	**144**	**126**	**112**	**101**	**92**	**84**	**78**	**72**	**67.2**	**63.**
725	348	261	209	174	149	131	116	104	95	87	80	75	69.6	65.3
750	360	270	216	180	154	135	120	108	98	90	83	77	72.	67.5
775	372	279	223	186	159	140	124	112	101	93	86	80	74.4	69.8
800	**384**	**288**	**230**	**192**	**165**	**144**	**128**	**115**	**105**	**96**	**89**	**82**	**76.8**	**72.**
825	396	297	238	198	170	149	132	119	108	99	91	85	79.2	74.3
850	408	306	245	204	175	153	136	122	111	102	94	87	81.6	76.5
875	420	315	252	210	180	158	140	126	115	105	97	90	84.	78.8
900	**432**	**324**	**259**	**216**	**185**	**162**	**144**	**130**	**118**	**108**	**100**	**93**	**86.4**	**81.**
925	444	333	266	222	190	167	148	133	121	111	103	95	88.8	83.3
950	456	342	274	228	195	171	152	137	124	114	105	98	91.2	85.5
975	468	351	281	234	201	176	156	140	128	117	108	100	93.6	87.8
1000	**480**	**360**	**288**	**240**	**206**	**180**	**160**	**144**	**131**	**121**	**111**	**103**	**96.**	**90.**

FLUE AREA REQUIRED FOR THE PASSAGE OF A GIVEN VOLUME OF AIR AT A GIVEN VELOCITY.—*Cont.*

Volume in Cu. Ft. per Min.	Velocity in Feet per Minute.													
	1700	1800	1900	2000	2100	2200	2300	2400	2600	2700	2800	2900	3000	3100
100	**8.5**	**8**	**7.6**	**7.2**	**6.9**	**6.6**	**6.3**	**6.**	**5.5**	**5.3**	**5.1**	**5.**	**4.8**	**4.6**
125	10.6	10	9.5	9.	8.6	8.2	7.8	7.5	6.9	6.7	6.4	6.2	6.	5.8
150	12.7	12	11.4	10.8	10.3	9.8	9.4	9.	8.	8.	7.7	7.5	7.2	7.
175	14.8	14	13.3	12.6	12.	11.5	11.	10.5	9.7	9.3	9.	8.7	8.4	8.1
200	**16.9**	**16**	**15.2**	**14.4**	**13.7**	**13.1**	**12.5**	**12.**	**11.1**	**10.7**	**10.3**	**9.9**	**9.6**	**9.3**
225	19.1	18	17.1	16.2	15.6	14.7	14.1	13.5	12.5	12.	11.6	11.2	10.8	10.4
250	21.2	20	19.	18.	17.1	16.4	15.7	15.	13.9	13.3	12.9	12.4	12.	11.6
275	23.3	22	21.8	19.8	18.9	18.	17.2	16.5	15.2	14.7	14.1	13.7	13.2	12.8
300	**25.4**	**24**	**22.7**	**21.6**	**20.6**	**19.6**	**18.8**	**18.**	**16.6**	**16.**	**15.4**	**14.9**	**14.4**	**13.9**
325	27.5	26	24.6	23.4	22.3	21.3	20.6	19.5	18.	17.3	16.7	16.1	15.8	15.1
350	29.6	28	26.5	25.2	24.	22.9	21.9	21.	19.4	18.7	18.	17.4	16.8	16.3
375	31.8	30	28.4	27.	25.7	24.5	23.5	22.5	20.8	20.	19.3	18.6	18.	17.4
400	**33.9**	**32**	**30.3**	**28.8**	**27.4**	**26.2**	**25.**	**24.**	**22.2**	**21.3**	**20.6**	**19.8**	**19.2**	**18.6**
425	36.	34	32.2	30.6	29.1	27.8	26.6	25.5	23.5	22.7	21.9	21.1	20.4	19.7
450	38.1	36	34.1	32.4	30.9	29.5	28.2	27.	24.9	24.	23.1	22.3	21.6	20.9
475	40.2	38	36.	34.2	32.6	31.1	29.7	28.5	26.3	25.3	24.4	23.6	22.8	22.1
500	**42.4**	**40**	**37.9**	**36.**	**34.3**	**32.7**	**31.3**	**30.**	**27.7**	**26.7**	**25.7**	**24.8**	**24.**	**23.2**
525	44.5	42	39.8	37.8	36.	34.4	32.9	31.5	29.1	28.	26.9	25.	25.2	24.4
550	46.6	44	41.7	38.6	37.7	36.	34.4	33.	30.5	29.3	28.3	27.3	26.4	25.5
575	48.7	46	43.6	41.4	39.4	37.6	36.	34.5	31.9	30.7	29.6	28.5	27.6	26.7
600	**50.8**	**48**	**45.5**	**43.2**	**41.1**	**39.3**	**37.6**	**36.**	**33.2**	**32.**	**30.8**	**29.8**	**28.8**	**27.8**
625	52.9	50	47.4	45.	42.9	40.9	39.1	37.5	34.6	33.3	32.1	31.	30.	29.
650	55.1	52	49.3	46.8	44.6	42.5	40.7	39.	36.	34.7	33.4	32.2	31.2	30.2
675	57.2	54	51.2	48.6	46.3	44.1	42.3	40.5	37.5	36.	34.7	33.5	32.4	31.3
700	**59.3**	**56**	**53.1**	**50.4**	**48.**	**45.8**	**43.8**	**42.**	**38.8**	**37.3**	**36.**	**34.7**	**33.6**	**32.5**
725	61.4	58	55.	52.2	49.7	47.4	45.4	43.5	40.2	38.7	37.3	36.	34.8	33.6
750	63.5	60	56.9	54.	51.4	49.1	47.	45.	41.5	40.	38.6	37.2	36.	34.8
775	65.6	62	58.8	56.3	53.1	50.7	48.5	46.5	42.9	41.3	39.9	38.5	37.2	36.
800	**67.8**	**64**	**60.6**	**57.6**	**54.9**	**52.4**	**50.1**	**48.**	**44.3**	**42.7**	**41.2**	**39.7**	**38.4**	**37.1**
825	69.9	66	62.5	59.4	56.6	54.	51.7	49.5	45.7	44.	42.4	40.9	39.6	38.3
850	72.	68	64.4	61.2	58.4	55.6	53.2	51.	47.1	45.3	43.7	42.2	40.8	39.4
875	74.	70	67.3	63.	60.	57.3	54.8	52.5	48.5	46.7	45.	43.4	42.	40.6
900	**76.2**	**72**	**68.2**	**64.8**	**61.7**	**58.9**	**56.3**	**54.**	**49.9**	**48.**	**46.3**	**44.6**	**43.2**	**41.8**
925	78.4	74	70.1	66.6	63.4	60.5	57.9	55.5	51.3	49.3	47.6	46.	44.4	42.9
950	80.5	76	72.	68.4	65.1	62.2	59.5	57.	52.6	50.7	48.8	47.1	45.6	44.1
975	82.6	78	73.9	70.2	66.8	63.8	61.0	58.5	54.	52.	50.2	48.4	46.8	45.3
1000	**84.7**	**80**	**75.8**	**72.**	**68.7**	**66.**	**62.6**	**60.**	**55.4**	**53.3**	**51.4**	**49.6**	**48.**	**46.4**

TABLES. *

The following tables will be found useful in estimating the size of registers, piping, and heating surface of pipes and boiler tubes:

TABLE OF SIZES AND DIMENSIONS OF SAFETY DOUBLE HOT-AIR STACKS.

Made by the Excelsior Steel Furnace Company.

Size of Stack as Listed, in Inches.	Actual Size of Outside Stack.	Actual Size of Inside Stack.	Area of Inside Stack, in Inches.	Capacity as Compared with that of Hot-air Pipe with Pitch of 1 Inch to 1 Foot.	Equivalent in Round Pipe with Pitch of 1 Inch to 1 Foot.	Sizes of Round Pipe which should be Used with Each Stack.	Area of Said Round Pipes, in Inches.	Size of Registers and Register-boxes which Should be Used with Each Stack.	Cubic Feet of Space (approximate) that can be Heated with Each Stack with Pipe and Registers of Size Given.	Equivalent of Said Space on Floor of Rooms 10 Feet High.	Area, in Inches, of Registers, with Space Occupied by Bars Deducted.
4×8	3⅝×7⅝	3¼×7	23	35	6½	7	38	6×8	500	6×8	35
4×10	3⅝×9⅝	3¼×9	29	43	7½	8	50	8×10	850	8×10	45
4×11	3⅝×10⅝	3¼×10	32½	48	8	8	50	8×12	1000	9×11	55
4×12	3⅝×11⅝	3¼×11	35	53	8¼	9	63	9×12	1250	10×12½	60
4×14	3⅝×13⅝	3¼×13	41	63	9	9	63	10×12	1650	12×14	70
6×10	5⅜×9⅝	5¼×9	47	71	10	10	78	10×14	2000	12×17	80
6×12	5⅜×11⅝	5¼×11	58	87	11	12	113	12×15	2300	14×17	115
6×14	5⅜×13⅝	5¼×13	68	102	12	12	113	12×17	2600	15×18	120
6×16	5⅜×15⅝	5¼×15	79	119	12½	14	154	14×20	3000	15×20	156
8×18	7⅜×17⅝	7¼×17	124	186	15	16	201	16×24	4000	20×20	210
10×20	9⅜×19⅝	9¼×19	176	264	18	18	254	20×24	5400	20×27	270
10×24	9¾×23⅝	9¼×23	213	330	20½	20	314	21×29	7000	20×35	340

* The following four pages have been taken from Kidder's Pocket Book by permission.

DIMENSIONS OF REGISTERS AND BORDERS.*

Made by the Tuttle & Bailey Manufacturing Co.

Size of Body.	Register.		Border.	
	Extreme Dimensions.	Depth Open.	With Ribs. Floor Opening.	Tin-box Size.
4×6	$5\frac{5}{8}\times7\frac{5}{8}$	$1\frac{5}{8}$		
4×8	$5\frac{1}{4}\times9\frac{1}{4}$	$2\frac{1}{4}$		
4×10	$5\frac{1}{4}\times11\frac{1}{4}$	$2\frac{1}{4}$		
4×13	$5\frac{1}{4}\times14\frac{1}{4}$	$2\frac{1}{4}$		
4×15	$5\frac{1}{4}\times16\frac{3}{16}$	$2\frac{1}{4}$		
4×18	$5\frac{1}{4}\times19\frac{1}{4}$	$2\frac{1}{4}$		
5×8	$6\frac{3}{8}\times9\frac{3}{8}$	2	$8\frac{1}{8}\times11\frac{1}{8}$	$5\frac{5}{16}\times8\frac{5}{16}$
5×11	$6\frac{3}{8}\times12\frac{3}{8}$	2	$8\frac{1}{8}\times14\frac{1}{8}$	$5\frac{5}{16}\times11\frac{5}{16}$
5×13	$6\frac{3}{8}\times14\frac{3}{8}$	2	$8\frac{1}{8}\times16\frac{1}{8}$	$5\frac{5}{16}\times13\frac{5}{16}$
5×16	$6\frac{3}{8}\times17\frac{3}{8}$	2	$8\frac{1}{8}\times19\frac{1}{8}$	$5\frac{5}{16}\times16\frac{5}{16}$
6×6	$7\frac{11}{16}\times7\frac{11}{16}$	$2\frac{3}{8}$	$9\frac{9}{16}\times9\frac{9}{16}$	$6\frac{9}{16}\times6\frac{9}{16}$
6×8	$7\frac{11}{16}\times9\frac{11}{16}$	$2\frac{3}{8}$	$9\frac{9}{16}\times11\frac{9}{16}$	$6\frac{9}{16}\times8\frac{9}{16}$
6×9	$7\frac{11}{16}\times10\frac{11}{16}$	$2\frac{3}{8}$	$9\frac{9}{16}\times12\frac{9}{16}$	$6\frac{9}{16}\times9\frac{9}{16}$
6×10	$7\frac{11}{16}\times11\frac{11}{16}$	$2\frac{3}{8}$	$9\frac{9}{16}\times13\frac{9}{16}$	$6\frac{9}{16}\times10\frac{9}{16}$
6×14	$7\frac{11}{16}\times15\frac{11}{16}$	$2\frac{3}{8}$	$9\frac{9}{16}\times17\frac{9}{16}$	$6\frac{9}{16}\times14\frac{9}{16}$
6×16	$7\frac{11}{16}\times17\frac{11}{16}$	$2\frac{3}{8}$	$9\frac{9}{16}\times19\frac{9}{16}$	$6\frac{9}{16}\times16\frac{9}{16}$
6×18	$7\frac{11}{16}\times19\frac{11}{16}$	$2\frac{3}{8}$	$9\frac{9}{16}\times21\frac{9}{16}$	$6\frac{9}{16}\times18\frac{9}{16}$
6×24	$7\frac{11}{16}\times25\frac{11}{16}$	$2\frac{3}{8}$	$9\frac{9}{16}\times27\frac{9}{16}$	$6\frac{9}{16}\times24\frac{9}{16}$
7×7	$8\frac{11}{16}\times8\frac{11}{16}$	$2\frac{3}{4}$	$10\frac{9}{16}\times10\frac{9}{16}$	$7\frac{9}{16}\times7\frac{9}{16}$
7×10	$8\frac{11}{16}\times11\frac{11}{16}$	$2\frac{3}{4}$	$10\frac{9}{16}\times13\frac{9}{16}$	$7\frac{9}{16}\times10\frac{9}{16}$
8×8†	$9\frac{3}{4}\times9\frac{3}{4}$	3	$11\frac{7}{8}\times11\frac{7}{8}$	$8\frac{5}{8}\times8\frac{5}{8}$
8×10	$9\frac{3}{4}\times11\frac{3}{4}$	3	$11\frac{7}{8}\times13\frac{7}{8}$	$8\frac{5}{8}\times10\frac{5}{8}$
8×12†	$9\frac{3}{4}\times13\frac{3}{4}$	3	$11\frac{7}{8}\times15\frac{7}{8}$	$8\frac{5}{8}\times12\frac{5}{8}$
8×15	$9\frac{3}{4}\times16\frac{11}{16}$	3	$11\frac{7}{8}\times18\frac{7}{8}$	$8\frac{5}{8}\times15\frac{5}{8}$
8×18	$9\frac{3}{4}\times19\frac{3}{4}$	3	$11\frac{7}{8}\times21\frac{7}{8}$	$8\frac{5}{8}\times18\frac{5}{8}$
8×21	$9\frac{3}{4}\times22\frac{3}{4}$	3	$11\frac{7}{8}\times24\frac{7}{8}$	$8\frac{5}{8}\times21\frac{5}{8}$
8×24	$9\frac{3}{4}\times25\frac{3}{4}$	3	$11\frac{7}{8}\times27\frac{7}{8}$	$8\frac{5}{8}\times24\frac{5}{8}$
9×9	$10\frac{7}{8}\times10\frac{7}{8}$	$3\frac{1}{4}$	$13\frac{1}{16}\times13\frac{1}{16}$	$9\frac{11}{16}\times9\frac{11}{16}$
9×12†	$10\frac{7}{8}\times13\frac{7}{8}$	$3\frac{1}{4}$	$13\frac{1}{16}\times16\frac{1}{16}$	$9\frac{11}{16}\times12\frac{11}{16}$
9×13	11×15	$3\frac{1}{4}$	$13\frac{1}{16}\times17\frac{1}{16}$	$9\frac{11}{16}\times13\frac{11}{16}$
9×14†	$10\frac{7}{8}\times15\frac{7}{8}$	$3\frac{1}{4}$	$13\frac{1}{16}\times18\frac{1}{16}$	$9\frac{11}{16}\times14\frac{11}{16}$
9×16	$10\frac{7}{8}\times17\frac{13}{16}$	$3\frac{1}{4}$	$13\frac{1}{16}\times20\frac{1}{16}$	$9\frac{11}{16}\times16\frac{11}{16}$
9×18	$10\frac{7}{8}\times19\frac{7}{8}$	$3\frac{1}{4}$	$13\frac{1}{16}\times22\frac{1}{16}$	$9\frac{11}{16}\times18\frac{11}{16}$
9×20	$10\frac{7}{8}\times21\frac{7}{8}$	$3\frac{1}{4}$	$13\frac{1}{16}\times24\frac{1}{16}$	$9\frac{11}{16}\times20\frac{11}{16}$
10×10	$11\frac{15}{16}\times11\frac{15}{16}$	$3\frac{3}{8}$	$14\frac{3}{16}\times14\frac{3}{16}$	$10\frac{11}{16}\times10\frac{11}{16}$
10×12	$11\frac{15}{16}\times13\frac{15}{16}$	$3\frac{3}{8}$	$14\frac{3}{16}\times16\frac{3}{16}$	$10\frac{11}{16}\times12\frac{11}{16}$
10×14	$12\times15\frac{15}{16}$	$3\frac{3}{8}$	$14\frac{3}{16}\times18\frac{3}{16}$	$10\frac{11}{16}\times14\frac{11}{16}$
10×16	$11\frac{15}{16}\times17\frac{7}{8}$	$3\frac{3}{8}$	$14\frac{3}{16}\times20\frac{3}{16}$	$10\frac{11}{16}\times16\frac{11}{16}$
10×18	$11\frac{15}{16}\times19\frac{7}{8}$	$3\frac{3}{8}$	$14\frac{3}{16}\times22\frac{3}{16}$	$10\frac{11}{16}\times18\frac{11}{16}$
10×20	$11\frac{15}{16}\times21\frac{7}{8}$	$3\frac{3}{8}$	$14\frac{3}{16}\times24\frac{3}{16}$	$10\frac{11}{16}\times20\frac{11}{16}$
12×12	$14\frac{1}{16}\times14\frac{1}{16}$	4	$16\frac{7}{16}\times16\frac{7}{16}$	$12\frac{13}{16}\times12\frac{13}{16}$
12×14	$14\frac{1}{16}\times16\frac{1}{16}$	4	$16\frac{7}{16}\times18\frac{7}{16}$	$12\frac{13}{16}\times14\frac{13}{16}$
12×15	$13\frac{13}{16}\times16\frac{15}{16}$	4	$16\frac{7}{16}\times19\frac{7}{16}$	$12\frac{13}{16}\times15\frac{13}{16}$

* For special side-wall registers, see p. 1201.

† These sizes are those most likely to be found in stock of local dealers.

DIMENSIONS OF REGISTERS AND BORDERS.—*Cont.*

Size of Body.	Register.		Border.	
	Extreme Dimensions.	Depth Open.	With Ribs. Floor Opening.	Tin-box Size.
12×16	$14\frac{1}{16}\times18$	4	$16\frac{7}{16}\times20\frac{7}{16}$	$12\frac{13}{16}\times16\frac{13}{16}$
12×17*	$14\frac{1}{16}\times19$	4	$16\frac{7}{16}\times21\frac{7}{16}$	$12\frac{13}{16}\times17\frac{13}{16}$
12×18	$14\frac{1}{16}\times20\frac{1}{16}$	4	$16\frac{7}{16}\times22\frac{7}{16}$	$12\frac{13}{16}\times18\frac{13}{16}$
12×19	$14\frac{1}{16}\times21\frac{1}{16}$	4	$16\frac{7}{16}\times23\frac{7}{16}$	$12\frac{13}{16}\times19\frac{13}{16}$
12×20	$14\frac{1}{16}\times22$	4	$16\frac{7}{16}\times24\frac{7}{16}$	$12\frac{13}{16}\times20\frac{13}{16}$
12×24	$14\frac{1}{16}\times26$	4	$16\frac{7}{16}\times28\frac{7}{16}$	$12\frac{13}{16}\times24\frac{13}{16}$
12×30	$14\frac{1}{16}\times32$	4		
12×36	$14\frac{1}{16}\times38$	4		
14×14	$16\frac{5}{16}\times16\frac{5}{16}$	4	$18\frac{15}{16}\times18\frac{15}{16}$	$14\frac{7}{8}\times14\frac{7}{8}$
14×16	$16\frac{5}{16}\times18\frac{5}{16}$	4	$18\frac{15}{16}\times20\frac{15}{16}$	$14\frac{7}{8}\times16\frac{7}{8}$
14×18	$16\frac{3}{8}\times20\frac{5}{16}$	4	$18\frac{15}{16}\times22\frac{15}{16}$	$14\frac{7}{8}\times18\frac{7}{8}$
14×20	$16\frac{5}{16}\times22\frac{5}{16}$	4	$18\frac{15}{16}\times24\frac{15}{16}$	$14\frac{7}{8}\times20\frac{7}{8}$
14×22	$16\frac{3}{8}\times24\frac{1}{4}$	4	$18\frac{15}{16}\times26\frac{15}{16}$	$14\frac{7}{8}\times22\frac{7}{8}$
15×25	$17\frac{11}{16}\times27\frac{11}{16}$	$4\frac{1}{2}$	$19\frac{13}{16}\times29\frac{15}{16}$	$16\frac{1}{8}\times26\frac{1}{4}$
16×16	$18\frac{5}{16}\times18\frac{5}{16}$	$4\frac{1}{4}$	$20\frac{7}{8}\times20\frac{7}{8}$	$16\frac{7}{8}\times16\frac{7}{8}$
16×18	$18\frac{5}{16}\times20\frac{5}{16}$	$4\frac{1}{4}$	$20\frac{7}{8}\times22\frac{7}{8}$	$16\frac{7}{8}\times18\frac{7}{8}$
16×20	$18\frac{1}{16}\times22\frac{5}{16}$	$4\frac{1}{4}$	$20\frac{7}{8}\times24\frac{7}{8}$	$16\frac{7}{8}\times20\frac{7}{8}$
16×22	$18\frac{5}{16}\times24\frac{5}{16}$	$4\frac{1}{4}$	$20\frac{7}{8}\times26\frac{7}{8}$	$16\frac{7}{8}\times22\frac{7}{8}$
16×24	$18\frac{5}{16}\times26\frac{11}{16}$	$4\frac{1}{4}$	$20\frac{7}{8}\times28\frac{7}{8}$	$16\frac{7}{8}\times25\frac{1}{4}$
16×28	$18\frac{5}{16}\times30\frac{5}{16}$	$4\frac{1}{4}$	$20\frac{7}{8}\times32\frac{7}{8}$	$16\frac{7}{8}\times28\frac{7}{8}$
16×32	$18\frac{5}{16}\times34\frac{5}{16}$	$4\frac{1}{4}$	$20\frac{7}{8}\times36\frac{7}{8}$	$16\frac{7}{8}\times32\frac{7}{8}$
18×18	$20\frac{5}{16}\times20\frac{5}{16}$	$4\frac{3}{4}$	$22\frac{15}{16}\times22\frac{15}{16}$	$18\frac{7}{8}\times18\frac{7}{8}$
18×21	$20\frac{5}{16}\times23\frac{5}{16}$	$4\frac{3}{4}$	$22\frac{15}{16}\times25\frac{15}{16}$	$18\frac{7}{8}\times21\frac{7}{8}$
18×24	$20\frac{5}{16}\times26\frac{5}{16}$	$4\frac{3}{4}$	$22\frac{15}{16}\times2$[illegible]$\frac{15}{16}$	$18\frac{7}{8}\times24\frac{7}{8}$
18×27	$20\frac{5}{16}\times29\frac{5}{16}$	$4\frac{3}{4}$	$22\frac{15}{16}\times31\frac{15}{16}$	$18\frac{7}{8}\times27\frac{7}{8}$
18×30	$20\frac{5}{16}\times32\frac{1}{4}$	$4\frac{3}{4}$	$22\frac{15}{16}\times34\frac{15}{16}$	$18\frac{7}{8}\times30\frac{7}{8}$
18×36	$20\frac{5}{16}\times38\frac{1}{4}$	$4\frac{3}{4}$	$22\frac{15}{16}\times40\frac{15}{16}$	$18\frac{7}{8}\times36\frac{7}{8}$
20×20	$22\frac{3}{8}\times22\frac{3}{8}$	$5\frac{1}{2}$	$25\frac{1}{8}\times25\frac{1}{8}$	$20\frac{15}{16}\times20\frac{15}{16}$
20×24	$22\frac{3}{8}\times26\frac{3}{8}$	$5\frac{1}{2}$	$25\frac{1}{8}\times29\frac{1}{8}$	$20\frac{15}{16}\times24\frac{15}{16}$
20×26*	$22\frac{9}{16}\times28\frac{5}{8}$	$5\frac{1}{2}$	$25\frac{1}{8}\times31\frac{1}{8}$	$20\frac{15}{16}\times26\frac{15}{16}$
21×29	$23\frac{3}{8}\times31\frac{3}{8}$	$5\frac{1}{2}$	$26\frac{1}{8}\times34\frac{1}{8}$	$21\frac{15}{16}\times29\frac{15}{16}$
24×24	$26\frac{7}{16}\times26\frac{7}{16}$	$5\frac{3}{8}$	$29\frac{1}{2}\times29\frac{1}{2}$	$24\frac{15}{16}\times24\frac{15}{16}$
24×27	$26\frac{7}{16}\times29\frac{3}{8}$	$5\frac{3}{8}$	$29\frac{1}{2}\times32\frac{1}{2}$	$24\frac{15}{16}\times27\frac{15}{16}$
24×30	$26\frac{7}{16}\times32\frac{3}{8}$	$5\frac{3}{8}$	$29\frac{1}{2}\times35\frac{1}{2}$	$24\frac{15}{16}\times30\frac{15}{16}$
24×32	$26\frac{7}{16}\times34\frac{3}{8}$	$5\frac{3}{8}$	$29\frac{1}{2}\times37\frac{1}{2}$	$24\frac{15}{16}\times32\frac{15}{16}$
24×36	$26\frac{7}{16}\times38\frac{3}{8}$	$5\frac{3}{8}$	$29\frac{1}{2}\times41\frac{1}{2}$	$24\frac{15}{16}\times36\frac{15}{16}$
24×45	$26\frac{7}{16}\times47\frac{3}{8}$	$5\frac{3}{8}$	$29\frac{1}{2}\times50\frac{1}{2}$	$24\frac{15}{16}\times45\frac{15}{16}$
27×27	$29\frac{7}{16}\times29\frac{7}{16}$	6	$32\frac{1}{2}\times32\frac{1}{2}$	$27\frac{15}{16}\times27\frac{15}{16}$
27×38	$29\frac{7}{16}\times40\frac{3}{8}$	$6\frac{1}{2}$	$32\frac{1}{2}\times43\frac{1}{2}$	$27\frac{15}{16}\times38\frac{15}{16}$
30×30	$32\frac{3}{8}\times32\frac{3}{8}$	$7\frac{3}{4}$	$35\frac{1}{2}\times35\frac{1}{2}$	$30\frac{15}{16}\times30\frac{15}{16}$
30×36	$32\frac{3}{8}\times38\frac{3}{8}$	$7\frac{3}{4}$	$35\frac{1}{2}\times41\frac{1}{2}$	$30\frac{15}{16}\times36\frac{15}{16}$
30×42	$32\frac{3}{8}\times44\frac{3}{8}$	$7\frac{3}{4}$	$35\frac{1}{2}\times47\frac{1}{2}$	$30\frac{15}{16}\times42\frac{15}{16}$

* These sizes are those most likely to be found in stock of local dealers.

ESTIMATED CAPACITY OF PIPES AND REGISTERS.

ROUND PIPES.

Diameter of Pipe.	Area in Sq. Inches.	Diameter of Pipe.	Area in Sq. Inches.	Diameter of Pipe.	Area in Sq. Inches.
7 inches	38	12 inches	113	22 inches	380
8 "	50	14 "	154	24 "	452
9 "	63	16 "	201	26 "	531
10 "	78	18 "	254	28 "	616
11 "	95	20 "	314	30 "	707

RECTANGULAR PIPES.

Size of Pipe.	Area in Sq. Inches.	Size of Pipe.	Area in Sq. Inches.	Size of Pipe.	Area in Sq. Inches.
4×8	32	8×20	160	12×18	216
4×10	40	8×24	192	12×20	240
4×12	48	10×12	120	12×24	288
4×16	64	10×15	150	14×14	196
6×10	60	10×16	160	14×16	224
6×12	72	10×18	180	14×20	280
6×16	96	10×20	200	16×16	256
8×10	80	12×12	144	16×18	288
8×12	96	12×15	180	16×20	320
8×16	128	12×16	192	16×24	384

REGISTERS.

Size of Opening.	Capacity in Sq. Inches.	Size of Opening.	Capacity in Sq. Inches.	Size of Opening.	Capacity in Sq. Inches.
6×10	40	10×14	93	20×20	267
8×10	53	10×16	107	20×24	320
8×12	64	12×15	120	20×26	347
8×15	80	12×19	152	21×29	406
9×12	72	14×22	205	27×27	486
9×14	84	15×25	250	27×38	684
10×12	80	16×24	256	30×30	600

ROUND REGISTERS.

Size of Opening.	Capacity in Sq. Inches.	Size of Opening.	Capacity in Sq. Inches.	Size of Opening.	Capacity in Sq. Inches.
7 inches	26	12 inches	75	20 inches	209
8 "	33	14 "	103	24 "	301
9 "	42	16 "	134	30 "	471
10 "	52	18 "	169	36 "	679

VELOCITY OF AIR DUE TO PRESSURE.

Temperature 50° Fahrenheit.

Pressure in Ounces per Sq. In.	Velocity in Feet per Sec.	Velocity in Feet per Min.	Pressure Ounces per Sq. In.	Velocity in Feet per Sec.	Velocity in Feet per Min.
1/8	30.47	1,828.4	5	190.76	11,445.5
1/4	43.08	2,585.0	5 1/4	195.37	11,722.0
3/8	52.75	3,165.1	5 1/2	199.86	11,991.5
1/2	60.90	3,653.8	5 3/4	204.25	12,254.8
5/8	68.07	4,084.0	6	208.53	12,511.9
3/4	74.54	4,472.6	6 1/2	216.82	13,009.3
7/8	80.50	4,829.7	7	224.77	13,486.4
1	86.03	5,161.7	7 1/2	232.42	13,945.4
1 1/8	91.22	5,473.4	8	239.80	14,387.9
1 1/4	96.13	5,768.0	8 1/2	246.92	14,815.4
1 3/8	100.80	6,047.9	9	253.83	15,229.6
1 1/2	105.25	6,315.2	9 1/2	260.52	15,631.0
1 5/8	109.52	6,571.3	10	267.00	16,020.4
1 3/4	113.64	6,817.6	10 1/2	273.32	16,399.3
1 7/8	117.58	7,055.0	11	279.70	16,768.1
2	121.41	7,284.4	11 1/2	285.46	17,127.6
2 1/8	125.11	7,506.7	12	291.30	17,478.2
2 1/4	128.70	7,722.2	12 1/2	297.01	17,820.6
2 3/8	132.20	7,931.8	13	302.59	18,155.2
2 1/2	135.59	8,135.7	13 1/2	308.04	18,482.4
2 5/8	138.91	8,334.4	14	313.38	18,802.7
2 3/4	142.14	8,528.3	14 1/2	318.61	19,116.3
2 7/8	145.29	8,717.6	15	323.73	19,423.6
3	148.38	8,902.8	15 1/2	328.75	19,725.0
3 1/8	151.40	9,084.0	16	333.68	20,020.7
3 1/4	154.36	9,261.5	16 1/2	338.51	20,310.8
3 3/8	157.26	9,435.4	17	343.26	20,595.8
3 1/2	160.10	9,606.1	17 1/2	347.93	20,875.8
3 5/8	162.89	9,773.3	18	352.52	21,151.0
3 3/4	165.63	9,938.0	18 1/2	357.03	21,421.6
3 7/8	168.33	10,099.6	19	361.46	21,687.8
4	170.98	10,258.6	19 1/2	365.83	21,949.7
4 1/4	176.15	10,568.8	20	370.13	22,207.5
4 1/2	181.16	10,869.5	....	....	....
4 3/4	186.03	11,161.5	....	....	....

Effects of Temperature.

	Degrees Fahr.
Titanium melts at	5432
Osmium melts at (Pictet)	4532
Rhodium melts at (Pictet)	3632
Ruthenium melts at (Devile & Debray)	3632
Indium melts at (Violle)	3532
Platinum melts at (Bredig)	3236
Palladium melts at (Bredig)	2888
Tungsten melts at	3092
Wrought Iron melts at (Pictet)	2912
Cast Iron melts at (Pouillet)	2786
Chromium melts at (E. A. Lewis)	2759
Cobalt melts at (Pictet)	2732
Nickel melts at (Bredig)	2703
Copper melts at (Kane) 1996, (Daniel)	2548
Gold melts at (Kane) 2200, (Morveau)	2518
Steel melts at	2400
Manganese melts at	2273
Silver melts at (Daniel)	2233
Brass melts at (Daniel)	1869
Bronze melts at (Roberts–Austin)	1692
Common Salt (Dr. J. A. Harker)	1472
Magnesium melts at (Roberts–Austin)	1200
Antimony melts at (I. Lowithan Bell) 955, (Dr. J. A. Harker)	1169
Aluminum melts at (Roberts–Austin)	1157
Iron, bright cherry red (Poilett)	1000
Iron, red heat, visible in daylight (Daniel)	980
Sulphur, at 760 mm. pressure, boils at (Dr. J. A. Harker)	833
Zinc begins to burn at (Daniel) 941, melts at (J. A. Harker)	786
Mercury boils at (Daniel & Graham)	662
Zinc melts at (Gmelin & Daniel)	648
Whale Oil boils at (Graham)	630
Sulphuric Acid boils at (Philips) 545, (Graham)	620
Pure Lead melts at (Parks) 612, (Daniel)	609
Cadmium melts at (Person)	609
Bismuth melts at (Gmelin) 518, (Philips)	476
Tin melts at (Person)	422
Arsenious Acid volatilizes at	380
Metallic Arsenic sublimes at	356
Indium melts at	348
Oil of Turpentine boils at (Kane)	315
Etherfication ends at	302
Linseed Oil boils at	260
Sat. Solution of Sal Ammoniac boils at (Taylor)	257
Sat. Solution of Acetate of Soda boils at	256
Sat. Solution of Nitric Acid 1–42 boils at	248
Sat. Solution of Sal Soda 1–4 boils at	248
Sat. Solution of Niter boils at	238
Sulphur melts at (Turner) 232, (Fownes)	226

	Degrees Fahr.
Sat. Solution of Alum, Carb. of Soda & Sul. of Zinc boils at	220
Sat. Solution of Chlorate and Prussiate of Potash boils at ..	218
Sat. Solution of Sulph. of Iron, Sulph. of Copper and Nitrate of Lead boils at	216
Sat. Solution of Acetate of Lead, Sulph. and Bitartrate of Potash boils at	214
Water begins to boil in glass at	213
Water begins to boil in metal, barometer at 30, at	212
Alloy of 5 Bismuth, 3 Tin, 2 Lead melts at	211
Alloy of 8 Bismuth, 5 Lead, 3 Tin, melts at (Kane)	201
Sodium begins to melt at	194
Starch dissolves in water at	180
Rectified Spirit boils at	176
Benzole distills at	176
Alcohol, sp. gr. 0.796 to 0.800, boils at	173
Beeswax melts at 151 (Kane)	151
Pyroxylic Spirit boils at (Scanlan)	150
Chloroform and Ammonia of 0.945 boils at	140
Potassium melts at (Daniel)	136
Acetone, Pyroacetic Spirit, boils at (Kane)	132
Mutton Suet and Styracine melts at	122
Bisulphide of Carbon boils at (Graham)	116
Pure Tallow melts at (Lepage)	115
Spermaceti and Stearine of Lard melts at	112
Phosphorus melts at	99
Ether, 0.720 boils at (temperature of the blood)	98
Acetous fermentation ceases at	88
Water boils in a vacuum at	88
Vineous fermentation ends, acetous fermentation begins at	77
Oil of Anise liquefies at	62
Sulphuric Acid, sp. gr. 1.741, congeals at	42
Olive Oil freezes at	36
Water freezes at	32
Milk freezes at	30
Vinegar freezes at	28
Wine freezes at	20
Cold produced by snow and salt	0
Brandy freezes at	–7
Mercury freezes at	–40
Liquid Oxygen boils at (Dr. J. A. Harker)	–295
Liquid Oxygen freezes or solidifies at	–400
Liquid Hydrogen boils at (Dr. J. A. Harker)	–423

Temperature of Flames.

According to the results of recent experiments the flame of acetylene is perhaps the hottest known except that of the electric arc. The following figures have been given by Mr. Maffi: Bunsen burner, 1871°; acetylene flame, 2548°; alcohol flame, 1705°;

Denayrouze burner, half alcohol, half petroleum, 2053°; hydrogen flame, in air, 1900°; gas jet flame, with oxygen, 2200°; oxyhydrogen flame, 2420°. These are all Centigrade degrees.

FUSION OF ALLOYS OF BISMUTH, TIN AND LEAD.

Bismuth Parts.	Lead Parts.	Tin Parts.	Temperature. Degrees F.	Bismuth Parts.	Lead Parts.	Tin Parts.	Temperature. Degrees F.
8	5	3	202	8	16	24	316
8	6	3	208	8	18	24	312
8	8	3	226	8	20	24	310
8	8	4	236	8	22	24	308
8	8	6	243	8	24	24	310
8	8	8	254	8	26	24	320
8	10	8	266	8	28	24	330
8	12	8	270	8	30	24	342
8	16	8	300	8	32	24	352
8	16	10	304	8	32	28	332
8	16	12	294	8	32	30	328
8	16	14	290	8	32	32	320
8	16	16	292	8	32	34	318
8	16	18	298	8	32	36	320
8	16	20	304	8	32	38	322
8	16	22	312	8	32	40	324

CONTENTS OF MARBLE SLABS.

The following tables will enable any person to compute the superficial contents of Marble Slabs from 6 × 12 to 47 × 62, the figures in the upper line showing the widths of Slabs, and figures in vertical column showing the lengths wanted.

To get the total polished surface add 1 inch for each finished edge.

For example: To ascertain the contents of a Slab 30 × 24 inches, with back 8 inches high, add 1 inch for each finished edge, making the Slab 32 × 25 inches, and size of back 32 × 9 inches. Find in side column the length, 32 inches, and in upper line the width, 25 inches. To the right of the 32-inch, and below the 25-inch size, will be found the contents of the Slab, 5 feet 7 inches. In the same manner find contents of back, 2 feet. Total, 7 feet 7 inches. Find contents of ends in same manner.

The inches in the tables indicate twelfths of a square foot.

CONTENTS OF MARBLE SLABS. — *Continued.*

Length. Inches.	Width in Inches.																				
	6 ft.in.	7 ft.in.	8 ft.in.	9 ft.in.	10 ft.in.	11 ft.in.	12 ft.in.	13 ft.in.	14 ft.in.	15 ft.in.	16 ft.in.	17 ft.in.	18 ft.in.	19 ft.in.	20 ft.in.	21 ft.in.	22 ft.in.	23 ft.in.	24 ft.in.	25 ft.in.	26 ft.in.
12	6	7	8	9	10	11	1														
13	7	8	9	10	11	1	1 1	1 2													
14	7	9	10	11	1	1 1	1 2	1 3	1 4												
15	8	9	10	1	1 1	1 2	1 3	1 4	1 6	1 7											
16	8	10	11	1	1 2	1 3	1 4	1 5	1 7	1 8	1 9										
17	9	10	1	1 1	1 3	1 4	1 5	1 6	1 8	1 9	1 11	2 2									
18	9	11	1	1 1	1 3	1 5	1 6	1 8	1 9	1 11	2	2 2	2 3								
19	10	11	1 1	1 3	1 4	1 6	1 7	1 9	1 10	2	2 1	2 3	2 5	2 6							
20	10	1	1 2	1 3	1 5	1 7	1 8	1 10	1 11	2 1	2 3	2 4	2 6	2 8	2 9						
21	11	1 1	1 2	1 4	1 6	1 8	1 9	1 11	2 1	2 2	2 4	2 6	2 8	2 9	2 11	3 1					
22	11	1 1	1 3	1 5	1 7	1 9	1 10	2	2 2	2 4	2 5	2 7	2 9	2 11	3 1	3 3	3 4				
23	1	1 2	1 4	1 6	1 8	1 9	1 11	2 1	2 3	2 5	2 7	2 9	2 11	3	3 2	3 4	3 6	3 8			
24	1	1 2	1 4	1 6	1 8	1 10	2	2 2	2 4	2 6	2 8	2 10	3	3 2	3 4	3 6	3 8	3 10	4		
25	1 1	1 3	1 5	1 7	1 9	1 11	2 1	2 3	2 5	2 7	2 9	2 11	3 2	3 4	3 6	3 8	3 10	4	4 2	4 4	
26	1 1	1 4	1 6	1 8	1 10	2	2 2	2 4	2 6	2 9	2 11	3 1	3 3	3 5	3 7	3 10	4	4 2	4 4	4 6	4 8
27	1 2	1 4	1 6	1 9	1 11	2 1	2 3	2 5	2 9	2 10	3	3 2	3 5	3 7	3 9	3 11	4 2	4 4	4 6	4 8	4 11
28	1 2	1 5	1 7	1 9	2	2 2	2 4	2 6	2 9	2 11	3 1	3 4	3 6	3 8	3 11	4 1	4 3	4 6	4 8	4 10	5 1
29	1 3	1 5	1 8	1 10	2 1	2 3	2 5	2 7	2 10	3	3 3	3 5	3 8	3 10	4	4 3	4 5	4 8	4 10	5	5 3
30	1 3	1 6	1 8	1 11	2 1	2 4	2 6	2 9	2 11	3 2	3 4	3 7	3 9	4	4 2	4 5	4 7	4 10	5	5 3	5 5
31	1 4	1 7	1 9	2	2 2	2 5	2 7	2 10	3 1	3 3	3 5	3 8	3 11	4 1	4 4	4 6	4 9	4 11	5 2	5 5	5 7
32	1 4	1 7	1 10	2	2 3	2 6	2 8	2 11	3	3 4	3 7	3 9	4	4 3	4 5	4 8	4 11	5 1	5 4	5 7	5 9
33	1 5	1 8	1 10	2 1	2 4	2 7	2 9	3	3 3	3 5	3 8	3 11	4 2	4 4	4 7	4 10	5 1	5 3	5 6	5 9	6
34	1 5	1 8	1 11	2 2	2 5	2 8	2 10	3 1	3 4	3 7	3 9	4	4 3	4 6	4 9	5	5 2	5 5	5 8	5 11	6 2
35	1 6	1 9	2	2 3	2 6	2 9	2 11	3 2	3 5	3 8	3 11	4 2	4 5	4 7	4 10	5 1	5 4	5 7	5 10	6 1	6 4
36	1 6	1 9	2	2 3	2 6	2 9	3	3 3	3 6	3 9	4	4 3	4 6	4 9	5	5 3	5 6	5 9	6	6 3	6 6
37	1 7	1 10	2 1	2 4	2 7	2 10	3 1	3 4	3 7	3 10	4 1	4 5	4 8	4 11	5 2	5 5	5 8	5 11	6 2	6 5	6 8
38	1 7	1 10	2 2	2 5	2 8	2 11	3 2	3 5	3 8	4	4 3	4 6	4 9	5	5 3	5 7	5 10	6 1	6 4	6 7	6 10
39	1 8	1 11	2 2	2 6	2 9	3	3 3	3 6	3 10	4 1	4 4	4 7	4 11	5 2	5 5	5 8	6	6 3	6 6	6 9	7 1
40	1 8	2	2 3	2 6	2 10	3 1	3 4	3 7	3 11	4 2	4 5	4 9	5	5 3	5 7	5 10	6 1	6 5	6 8	6 11	7 3
41	1 9	2	2 3	7	2 11	3 2	3 5	3 8	4	4 3	4 7	4 10	5 2	5 5	5 8	6	6 3	6 7	6 10	7 1	7 5
42	1 9	2 1	2 4	2 8	2 11	3 3	3 6	3 10	4 1	4 5	4 8	5	5 3	5 7	5 10	6 2	6 5	6 9	7	7 4	7 7
43	1 10	2 1	2 5	2 8	3	3 4	3 7	3 11	4 2	4 6	4 9	5 1	5 5	5 8	6	6 3	6 7	6 10	7 2	7 6	7 9
44	1 10	2 2	2 6	2 9	3 1	3 5	3 8	4	4 3	4 7	4 11	5 2	5 6	5 10	6 1	6 5	6 9	7	7 4	7 8	7 11
45	1 11	2 3	2 6	2 10	3 2	3 6	3 9	4 1	4 5	4 8	5	5 4	5 8	5 11	6 3	6 7	6 11	7 2	7 6	7 10	8 2
46	1 11	2 3	2 7	2 11	3 3	3 7	3 10	4 2	4 6	4 10	5 1	5 5	5 9	6 1	6 5	6 9	7	7 4	7 8	8	8 4
47	2	2 4	2 8	3	3 4	3 7	3 11	4 3	4 7	4 11	5 3	5 7	5 11	6 2	6 6	6 10	7 2	7 6	7 10	8 2	8 6

CONTENTS OF MARBLE SLABS. — *Continued.*

Length. Inches.	Width in Inches.																				
	27 ft. in.	28 ft. in.	29 ft. in.	30 ft. in.	31 ft. in.	32 ft. in.	33 ft. in.	34 ft. in.	35 ft. in.	36 ft. in.	37 ft. in.	38 ft. in.	39 ft. in.	40 ft. in.	41 ft. in.	42 ft. in.	43 ft. in.	44 ft. in.	45 ft. in.	46 ft. in.	47 ft. in.
27	5 1																				
28	5 3	5 5																			
29	5 5	5 8	5 10																		
30	5 8	5 10	6 1	6 3																	
31	5 10	6	6 3	6 6	6 8																
32	6	6 3	6 5	6 8	6 11	7 1															
33	6 2	6 5	6 8	6 11	7 1	7 4	7 7														
34	6 5	6 7	6 10	7 1	7 4	7 7	7 10	8													
35	6 7	6 10	7 1	7 4	7 6	7 9	8	8 3	8 6												
36	6 9	7	7 3	7 6	7 9	8	8 3	8 6	8 9	9											
37	6 11	7 2	7 5	7 9	8	8 3	8 6	8 9	9	9 3	9 6										
38	7 2	7 5	7 8	7 11	8 2	8 5	8 9	9	9 3	9 6	9 9	10									
39	7 4	7 7	7 10	8 2	8 5	8 8	8 11	9 3	9 6	9 9	10	10 4	10 7								
40	7 6	7 9	8 1	8 4	8 7	8 11	9 2	9 5	9 9	10	10 3	10 7	10 10	11 1							
41	7 8	8	8 3	8 7	8 10	9 1	9 5	9 8	10	10 3	10 6	10 10	11 1	11 5	11 8						
42	7 11	8 2	8 6	8 9	9 1	9 4	9 8	9 11	10 2	10 6	10 10	11 1	11 5	11 8	12	12 3					
43	8 1	8 4	8 8	9	9 3	9 7	9 10	10 2	10 5	10 9	11 1	11 4	11 8	11 11	12 3	12 7	12 10				
44	8 3	8 7	8 10	9 2	9 6	9 9	10 1	10 5	10 8	11	11 4	11 7	11 11	12 3	12 6	12 10	13 2	13 5			
45	8 5	8 9	9 1	9 5	9 8	10	10 4	10 8	10 11	11 3	11 7	11 11	12 2	12 6	12 10	13 3	13 5	13 9	14		
46	8 8	9	9 4	9 7	9 11	10 3	10 7	10 10	11 2	11 6	11 10	12 2	12 6	12 9	13 1	13 5	13 9	14 1	14 5	14 8	
47	8 10	9 2	9 6	9 10	10 1	10 5	10 9	11 1	11 5	11 9	12 1	12 5	12 9	13 1	13 5	13 9	14	14 4	14 8	15	15 4
48	.....	.....	.....	10	10 4	10 8	11	11 4	11 8	12	12 4	12 8	13	13 4	13 8	14	14 4	14 8	15	15 4	15 8
49	.....	.....	.....	10 3	10 7	10 11	11 3	11 7	11 11	12 3	12 7	12 11	13 3	13 7	13 11	14 4	14 8	15	15 4	15 8	16
50	.....	.....	.....	10 5	10 9	11 1	11 6	11 10	12 2	12 6	12 10	13 2	13 7	13 11	14 3	14 7	14 11	15 3	15 8	16	16 4
51	.....	.....	.....	10 8	11	11 4	11 8	12 1	12 5	12 9	13 1	13 6	13 10	14 2	14 6	14 11	15 3	15 7	15 11	16 4	16 8
52	.....	.....	.....	10 10	11 2	11 7	11 11	12 3	12 8	13	13 4	13 9	14 1	14 5	14 10	15 2	15 6	15 11	16 3	16 7	17
53	.....	.....	.....	11 1	11 5	11 9	12 2	12 6	12 11	13 3	13 7	14	14 4	14 9	15 1	15 6	15 10	16 2	16 7	16 11	17 4
54	.....	.....	.....	11 3	11 8	12	12 5	12 9	13 2	13 6	13 11	14 3	14 8	15	15 5	15 9	16 2	16 6	16 11	17 3	17 8
55	.....	.....	.....	11 6	11 10	12 3	12 7	13	13 4	13 9	14 2	14 6	14 11	15 3	15 8	16 1	16 5	16 10	17 2	17 7	17 11
56	.....	.....	.....	11 8	12 1	12 5	12 10	13 3	13 7	14	14 5	14 9	15 2	15 7	15 11	16 4	16 9	17 1	17 6	17 11	18 3
57	.....	.....	.....	11 11	12 3	12 8	13 1	13 6	13 10	14 3	14 8	15 1	15 5	15 10	16 3	16 8	17	17 5	17 10	18 3	18 7
58	.....	.....	.....	12 1	12 6	12 11	13 4	13 8	14 1	14 6	14 11	15 4	15 9	16 1	16 6	16 11	17 4	17 9	18 2	18 6	18 11
59	.....	.....	.....	12 4	12 8	13 1	13 6	13 11	14 4	14 9	15 2	15 7	16	16 5	16 10	17 3	17 7	18	18 5	18 10	19 3
60	.....	.....	.....	12 6	12 11	13 4	13 9	14 2	14 7	15	15 5	15 10	16 3	16 8	17 1	17 6	17 11	18 4	18 9	19 2	19 7
61	.....	.....	.....	12 9	13 2	13 7	14	14 5	14 10	15 3	15 8	16 1	16 6	16 11	17 4	17 10	18 3	18 8	19 1	19 6	19 11
62	.....	.....	.....	12 11	13 4	13 9	14 3	14 8	15 1	15 6	15 11	16 4	16 10	17 3	17 8	18 1	18 6	18 11	19 5	19 10	20 3

LENGTH OF WIPE JOINTS FOR LEAD PIPE.

Diameter Pipe, Inches.	Length Joint, Inches.	Diameter Pipe, Inches.	Length Joint, Inches.	Diameter Pipe, Inches.	Length Joint, Inches
$\frac{1}{2}$	$2\frac{1}{2}$	$1\frac{1}{4}$ water	$3\frac{1}{4}$	2 waste	$2\frac{1}{4}$
$\frac{5}{8}$	$2\frac{1}{2}$	$1\frac{1}{4}$ waste	2	$2\frac{1}{2}$ waste	$2\frac{1}{2}$
$\frac{3}{4}$	$2\frac{3}{4}$	$1\frac{1}{2}$ water	$3\frac{1}{2}$	3 waste	$2\frac{1}{2}$
1	3	$1\frac{1}{2}$ waste	$2\frac{1}{4}$	4 waste	3

Solder Required for Wipe Joints.

$\frac{1}{2}$ inch pipe takes.............................. $\frac{3}{4}$ pound.
$\frac{3}{4}$ inch pipe takes..............................1 pound.
1 inch pipe takes..............................$1\frac{1}{4}$ pounds.
$1\frac{1}{4}$ inch pipe takes..............................$1\frac{1}{2}$ pounds.
$1\frac{1}{2}$ inch pipe takes..............................$1\frac{3}{4}$ pounds.
$1\frac{3}{4}$ inch pipe takes..............................2 pounds.
2 inch pipe takes..............................$2\frac{1}{4}$ pounds.

Branch Pipe.

$1\frac{1}{4}$ inch pipe.................................. 9 oz.
$1\frac{1}{2}$ inch pipe.................................. $9\frac{1}{2}$ oz.
2 inch pipe..................................$10\frac{1}{4}$ oz.

Amounts liberal for good sized joint.

Shaving for Lead Joints.

Diameter. Shaving.

$\frac{1}{2}$ inch ....$2\frac{1}{2}$ in. long.
$\frac{3}{4}$ inch ....$2\frac{3}{4}$ in. long.
1 inch ....3 in. long.
$1\frac{1}{4}$ inch ....$3\frac{1}{4}$ in. long.
$1\frac{1}{2}$ inch ....$3\frac{1}{2}$ in. long.
2 inch ....4 in. long.
3 inch ....$3\frac{1}{2}$ in.-4 in. long.
4 inch ....$3\frac{1}{2}$ in.-4 in. long.
5 inch and all
sizes over ....4 in. long.

WEIGHT OF LEAD REQUIRED FOR JOINTS OF CAST IRON SOCKET PIPES.

Diameter of Pipe, Inches.	Weight Lead, Pounds.	Diameter of Pipe, Inches.	Weight Lead, Pounds.
2	2	10	12
2½	2½	11	13½
3	3	12	15
4	3¾	14	18
5	6	15	22
6	7	16	24
7	8	18	25
8	9	20	27
9	10½	24	38

SPACING OF LEAD PIPE TACKS.

Size of Pipe, Inches.	Vertical Pipe, Inches.		Horizontal Pipe, Inches.	
	Hot.	Cold.	Hot.	Cold.
⅜	18	24	12	16
½	19	25	14	17
⅝	20	26	15	18
¾	21	27	16	19
1	22	28	17	20
1¼	23	29	18	21
1½	24	30	18	22

Tacks are spaced closer on hot than on cold pipes, as lead is much more liable to sag when heated.

FUSING POINTS OF SOLDER.

Percentage, Tin.	Percentage, Lead.	Fusing Point.
83.3	16.7	401° F.
69.5	30.5	368.6° F.
63.0	37.0	357.8° F.
53.2	46.8	368.6° F.
50.0	50.0	395.6° F.
45.6	54.4	410° F.
36.2	63.8	455° F.
27.2	72.8	474.8° F.
22.1	77.9	518° F.
15.9	84.1	541° F.
12.4	87.6	557.6° F.

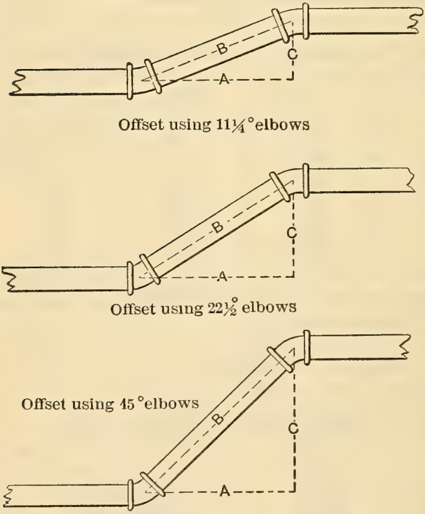
Solder fuses at a lower temperature than either component.

MELTING POINTS OF FUSIBLE PLUGS.

	Softens.	Melts at
2 tin 2 lead	365°	372°
2 tin 6 lead	372°	383°
2 tin 7 lead	377½°	388°
2 tin 8 lead	395½°	408°

Lengths of Diagonals of Offsets.

The following table gives the lengths of diagonals of angles of 45, 22½, and 11¼ degrees, or offsets using elbows of these angles as shown in Fig. 62. For instance it is desired to make an offset in a run of pipe at an angle of 22½ degrees, and the distance *A* is known as, say 1 ft. 7 in.; We look in the table under length of *A*, and find 1 ft. 7 in., and continuing this line out to the diagonal column for 22½ degree angle we find 1 ft. 8$\frac{9}{16}$ in., which is the length of the diagonal to make the desired offset measuring from centers of the fittings, as shown.



B = The diagonal in table
C = The short side in table

Fig. 62. Diagram of Offsets.

In case the distance *C* or short leg is known then find that length in the short leg column under the desired angle and the diagonal will be given in the diagonal column under this angle.

In using this table the measurements must always be taken from the center of the fitting.

TABLE OF ANGLES OR OFFSETS.

Length of Leg A.		Length of Diagonal.								
		45° Angle. or Offset.		$22\frac{1}{2}$° Angle. or Offset.				$11\frac{1}{4}$° Angle or Offset.		
		Diagonal.		Short Leg.		Diagonal.		Short Leg.	Diagonal.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	in.	ft.	in.
	1		$1\frac{7}{16}$		$\frac{7}{16}$		$1\frac{1}{16}$	$\frac{3}{16}$		1
	2		$2\frac{13}{16}$		$\frac{13}{16}$		$2\frac{3}{16}$	$\frac{3}{8}$		$2\frac{1}{16}$
	3		$4\frac{1}{4}$		$1\frac{1}{4}$		$3\frac{1}{4}$	$\frac{5}{8}$		$3\frac{1}{16}$
	4		$5\frac{5}{8}$		$1\frac{11}{16}$		$4\frac{5}{16}$	$\frac{13}{16}$		$4\frac{1}{16}$
	5		$7\frac{1}{16}$		$2\frac{1}{16}$		$5\frac{7}{16}$	1		$5\frac{1}{8}$
	6		$8\frac{1}{2}$		$2\frac{1}{2}$		$6\frac{1}{2}$	$1\frac{3}{16}$		$6\frac{1}{8}$
	7		$9\frac{7}{8}$		$2\frac{7}{8}$		$7\frac{9}{16}$	$1\frac{3}{8}$		$7\frac{1}{8}$
	8		$11\frac{5}{16}$		$3\frac{5}{16}$		$8\frac{11}{16}$	$1\frac{9}{16}$		$8\frac{1}{8}$
	9		$12\frac{3}{4}$		$3\frac{3}{4}$		$9\frac{3}{4}$	$1\frac{13}{16}$		$9\frac{3}{16}$
	10	1	$2\frac{1}{8}$		$4\frac{1}{8}$		$10\frac{13}{16}$	2		$10\frac{3}{16}$
	11	1	$3\frac{9}{16}$		$4\frac{9}{16}$		$11\frac{7}{8}$	$2\frac{3}{16}$		$11\frac{3}{16}$
	12	1	5		5	1	1	$2\frac{3}{8}$	1	$\frac{1}{4}$
1	1	1	$6\frac{3}{8}$		$5\frac{3}{8}$	1	$2\frac{1}{16}$	$2\frac{9}{16}$	1	$1\frac{1}{4}$
1	2	1	$7\frac{13}{16}$		$5\frac{13}{16}$	1	$3\frac{1}{8}$	$2\frac{3}{4}$	1	$2\frac{5}{16}$
1	3	1	$9\frac{3}{16}$		$6\frac{1}{4}$	1	$4\frac{1}{4}$	3	1	$3\frac{5}{16}$
1	4	1	$10\frac{5}{8}$		$6\frac{11}{16}$	1	$5\frac{5}{16}$	$3\frac{3}{16}$	1	$4\frac{5}{16}$
1	5	2	$\frac{1}{16}$		$7\frac{1}{16}$	1	$6\frac{3}{8}$	$3\frac{3}{8}$	1	$5\frac{3}{8}$
1	6	2	$1\frac{7}{16}$		$7\frac{1}{2}$	1	$7\frac{1}{2}$	$3\frac{9}{16}$	1	$6\frac{3}{8}$
1	7	2	$2\frac{7}{8}$		$7\frac{7}{8}$	1	$8\frac{9}{16}$	$3\frac{3}{4}$	1	$7\frac{3}{8}$
1	8	2	$4\frac{5}{16}$		$8\frac{5}{16}$	1	$9\frac{5}{8}$	$3\frac{15}{16}$	1	$8\frac{3}{8}$
1	9	2	$5\frac{11}{16}$		$8\frac{3}{4}$	1	$10\frac{3}{4}$	$4\frac{3}{16}$	1	$9\frac{7}{16}$
1	10	2	$7\frac{1}{8}$		$9\frac{1}{8}$	1	$11\frac{13}{16}$	$4\frac{3}{8}$	1	$10\frac{7}{16}$
1	11	2	$8\frac{1}{2}$		$9\frac{9}{16}$	2	$\frac{7}{8}$	$4\frac{9}{16}$	1	$11\frac{7}{16}$
2		2	$9\frac{15}{16}$		$9\frac{15}{16}$	2	2	$4\frac{3}{4}$	2	$\frac{1}{2}$
2	1	2	$11\frac{3}{8}$		$10\frac{3}{8}$	2	$3\frac{1}{16}$	$4\frac{15}{16}$	2	$1\frac{1}{2}$
2	2	3	$\frac{3}{4}$		$10\frac{3}{4}$	2	$4\frac{1}{8}$	$5\frac{1}{8}$	2	$2\frac{9}{16}$
2	3	3	$2\frac{3}{16}$		$11\frac{3}{16}$	2	$5\frac{1}{4}$	$5\frac{3}{8}$	2	$3\frac{9}{16}$
2	4	3	$3\frac{5}{16}$		$11\frac{5}{8}$	2	$6\frac{5}{16}$	$5\frac{9}{16}$	2	$4\frac{9}{16}$
2	5	3	5	1	0	2	$7\frac{3}{8}$	$5\frac{3}{4}$	2	$5\frac{5}{8}$
2	6	3	$6\frac{7}{16}$	1	$\frac{7}{16}$	2	$8\frac{1}{2}$	$5\frac{15}{16}$	2	$6\frac{5}{8}$
2	7	3	$7\frac{13}{16}$	1	$1\frac{3}{16}$	2	$9\frac{9}{16}$	$6\frac{1}{8}$	2	$7\frac{5}{8}$
2	8	3	$9\frac{1}{4}$	1	$1\frac{1}{4}$	2	$10\frac{5}{8}$	$6\frac{5}{16}$	2	$8\frac{5}{8}$
2	9	3	$10\frac{11}{16}$	1	$1\frac{11}{16}$	2	$11\frac{11}{16}$	$6\frac{9}{16}$	2	$9\frac{11}{16}$
2	10	4	$\frac{1}{16}$	1	$2\frac{1}{16}$	3	$\frac{13}{16}$	$6\frac{3}{4}$	2	$10\frac{11}{16}$
2	11	4	$1\frac{1}{2}$	1	$2\frac{1}{2}$	3	$1\frac{7}{8}$	$6\frac{15}{16}$	2	$11\frac{11}{16}$
3		4	$2\frac{15}{16}$	1	$2\frac{15}{16}$	3	$2\frac{15}{16}$	$7\frac{3}{16}$	3	$\frac{11}{16}$

TABLE OF ANGLES OR OFFSETS. — *Continued.*

Length of Leg A.		Length of Diagonal.									
		45° Angle or Offset.		22½° Angle or Offset.				11¼° Angle or Offset.			
Sides.		Diagonal.		Short Leg.		Diagonal.		Short Leg.		Diagonal.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
3	1	4	4 5/16	1	3 5/16	3	4 1/16		7 3/8	3	1 11/16
3	2	4	5 3/4	1	3 3/4	3	5 1/8		7 9/16	3	2 3/4
3	3	4	7 3/16	1	4 1/8	3	6 3/16		7 13/16	3	3 3/4
3	4	4	8 9/16	1	4 9/16	3	7 5/16		8	3	4 3/4
3	5	4	10	1	5	3	8 3/8		8 3/16	3	5 13/16
3	6	4	11 3/8	1	5 3/8	3	9 7/16		8 3/8	3	6 13/16
3	7	5	13/16	1	5 13/16	3	10 9/16		8 9/16	3	7 13/16
3	8	5	2 1/4	1	6 1/4	3	11 5/8		8 3/4	3	8 13/16
3	9	5	3 5/8	1	6 5/8	4	11/16		9	3	9 7/8
3	10	5	5 1/16	1	7 1/16	4	1 13/16		9 3/16	3	10 7/8
3	11	5	6 7/16	1	7 7/16	4	2 7/8		9 3/8	3	11 7/8
4		5	7 7/8	1	7 7/8	4	3 15/16		9 9/16	4	15/16
4	1	5	9 15/16	1	8 5/16	4	5 1/16		9 3/4	4	1 15/16
4	2	5	10 11/16	1	8 11/16	4	6 1/8		9 15/16	4	3
4	3	6	1/8	1	9 1/8	4	7 3/16		10 3/16	4	4
4	4	6	1 9/16	1	9 9/16	4	8 5/16		10 3/8	4	5
4	5	6	2 15/16	1	9 15/16	4	9 3/8		10 9/16	4	6 1/16
4	6	6	4 3/8	1	10 3/8	4	10 7/16		10 3/4	4	7 1/16
4	7	6	5 3/4	1	10 3/4	4	11 1/2		10 15/16	4	8 1/16
4	8	6	7 13/16	1	11 3/16	5	5/8		11 1/8	4	9 1/16
4	9	6	8 5/8	1	11 5/8	5	1 11/16		11 3/8	4	10 1/8
4	10	6	10	2	0	5	2 3/4		11 5/8	4	11 1/8
4	11	6	11 7/16	2	7/16	5	3 7/16		11 13/16	5	1/8
5		7	7/8	2	7/8	5	4 15/16	1	0	5	1 3/16
5	1	7	2 1/4	2	1 1/4	5	6	1	3/16	5	2 3/16
5	2	7	3 11/16	2	1 11/16	5	7 1/8	1	3/8	5	3 1/4
5	3	7	5 1/16	2	2 1/8	5	8 3/16	1	5/8	5	4 1/4
5	4	7	6 1/2	2	2 1/2	5	9 1/4	1	13/16	5	5 1/4
5	5	7	7 15/16	2	2 15/16	5	10 3/8	1	1	5	6 5/16
5	6	7	9 15/16	2	3 5/16	5	11 7/16	1	1 3/16	5	7 5/16
5	7	7	10 3/4	2	3 3/4	6	1/2	1	1 3/8	5	8 5/16
5	8	8	3/16	2	4 3/16	6	1 5/8	1	1 9/16	5	9 5/16
5	9	8	1 9/16	2	4 9/16	6	2 11/16	1	1 3/4	5	10 3/8
5	10	8	3	2	5	6	3 3/4	1	1 15/16	5	11 3/8
5	11	8	4 7/16	2	5 3/8	6	4 7/8				
6		8	5 13/16	2	5 13/16	6	5 15/16				

The length of the diagonal B., Fig. 62, can also be found by multiplying the length of the offset or short leg by the following multiples:

45	degrees,	offset,	multiply	by	1.414
60	"	"	"	"	1.150
30	"	"	"	"	2.000
$22\frac{1}{2}$	"	"	"	"	2.610
$11\frac{1}{4}$	"	"	"	"	5.120
$5\frac{5}{8}$	"	"	"	"	10.20

Or by multiplying the long leg by the following:

$5\frac{5}{8}$	degrees,	offset,	multiply	by	1.004
$11\frac{1}{4}$	"	"	"	"	1.019
$22\frac{1}{2}$	"	"	"	"	1.082
30	"	"	"	"	1.150
45	"	"	"	"	1.414
60	"	"	"	"	2.000

Computing Sizes of Drains.

There is no definite rule for figuring the sizes of drains, and it is more or less a matter of judgment. The following, taken from the Cleveland Plumbing ordinance, is believed to be a safe rule to follow.

Twenty square feet roof or yard area counts as 1 fixture.

Three feet of urinal trough or wash sink counts as 1 fixture.

One bath, basin, or sink counts as 1 fixture.

One pedestal urinal or slop sink counts as 2 fixtures.

One water-closet counts as 4 fixtures.

In connection with the above the sizes of drains are given as follows:

Size Main Drain.	Soil, Waste and Rain Water.	Soil and Waste.	Soil Alone.
4 in.	163 fix. or less	72 fixtures	12 w.c.
5 in.	300 fix. or less	144 fixtures	25 w.c.
6 in.	488 fix. or less	250 fixtures	42 w.c.
7 in.	722 fix. or less	410 fixtures	70 w.c.
8 in.	1000 fix. or less	610 fixtures	105 w.c.
9 in.	1334 fix. or less	850 fixtures	145 w.c.
10 in.	1750 fix. or less	1200 fixtures	200 w.c.

TABLES OF STANDARD DIAMETERS, OF FLANGES, AND DRILLING AND BOLTING OF FLANGED VALVES.

Dimensions given are those adopted by the Master Steam and Hot Water Fitters' Association, the Society of Mechanical Engineers of the United States, and Valve and Fitting Manufacturers. This standard is commonly known as the "Steam Fitters' Standard."

FOR "LIGHT" VALVES.

	Sizes, Inches.						
	6	8	10	12	14	15	16
Diameter of flanges.........	11	$13\frac{1}{2}$	16	19	21	$22\frac{1}{4}$	$23\frac{1}{2}$
Diameter of bolt circle......	$9\frac{1}{2}$	$11\frac{3}{4}$	$14\frac{1}{4}$	17	$18\frac{3}{4}$	20	$21\frac{1}{4}$
Number of bolts............	8	8	12	12	12	16	16
Size of bolts........ (Diam.)	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$

	Sizes, Inches.						
	18	20	24	30	36	42	48
Diameter of flanges.........	25	$27\frac{1}{2}$	$31\frac{1}{2}$	38	$44\frac{1}{2}$	51	$57\frac{1}{2}$
Diameter of bolt circle......	$22\frac{3}{4}$	25	$29\frac{1}{4}$	$35\frac{1}{2}$	42	$48\frac{1}{2}$	$54\frac{3}{4}$
Number of bolts............	16	20	20	28	32	36	44
Size of bolts........ (Diam.)	1	1	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$

FOR "STANDARD" VALVES, AND FOR "VALVES FOR 125 POUNDS WORKING STEAM PRESSURE."

	Sizes, Inches.					
	2	2½	3	3½	4	4½
Diameter of flanges	6	7	7½	8½	9	9¼
Diameter of bolt circle	4¾	5½	6	7	7½	7¾
Number of bolts	4	4	4	4	4	8
Size of bolts (Diam.) According to pressure	½ ⅝	½ ⅝	½ ⅝	½ ⅝	⅝ ¾	⅝ ¾

	Sizes, Inches.					
	5	6	7	8	9	10
Diameter of flanges	10	11	12½	13½	15	16
Diameter of bolt circle	8½	9½	10¾	11¾	13¼	14¼
Number of bolts	8	8	8	8	12	12
Size of bolts (Diam.) According to pressure	⅝ ¾	⅝ ¾	⅝ ¾	⅝ ¾	⅝ ¾	¾ ⅞

	Sizes, Inches.					
	12	14	16	18	20	22
Diameter of flanges	19	21	23½	25	27½	29½
Diameter of bolt circle	17	18¾	21¼	22¾	25	27¼
Number of bolts	12	12	16	16	20	20
Size of bolts (Diam.) According to pressure	¾ ⅞	⅞ 1	⅞ 1	1 1⅛	1 1⅛	1 1¼

	Sizes, Inches.				
	24	30	36	42	48
Diameter of flanges	32	38¾	45¾	52¾	59½
Diameter of bolt circle	29½	36	42¾	49½	56
Number of bolts	20	28	32	36	44
Size of bolts (Diam.) According to pressure	1 1¼	1⅛ 1⅜	1⅛ 1⅜	1¼ 1½	1⅜ 1½

The following table is adapted by the leading Valve and Fitting Manufacturers.

FOR " MEDIUM HEAVY " AND " EXTRA HEAVY " VALVES.

	Sizes, Inches.							
	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	6	7
Diameter of flanges	$7\frac{1}{2}$	$8\frac{1}{4}$	9	10	$10\frac{1}{2}$	11	$12\frac{1}{2}$	14
Diameter of bolt circle..	$5\frac{7}{8}$	$6\frac{5}{8}$	$7\frac{1}{4}$	$7\frac{7}{8}$	$8\frac{1}{2}$	$9\frac{1}{4}$	$10\frac{5}{8}$	$11\frac{7}{8}$
Number of bolts	4	8	8	8	8	8	12	12
Size of bolts.... (Diam.)	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{7}{8}$

	Sizes, Inches.							
	8	9	10	12	14	16	18	20
Diameter of flanges	15	16	$17\frac{1}{2}$	20	$22\frac{1}{2}$	25	27	$29\frac{1}{2}$
Diameter of bolt circle..	13	14	$15\frac{1}{4}$	$17\frac{3}{4}$	20	$22\frac{1}{2}$	$24\frac{1}{2}$	$26\frac{3}{4}$
Number of bolts	12	12	16	16	20	20	24	24
Size of bolts .... (Diam.)	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	1	1	$1\frac{1}{8}$

WEIGHT, ETC., OF SKYLIGHT GLASS.

THE WEIGHTS OF VARIOUS SIZES AND THICKNESSES OF FLUTED OR PLATE GLASS REQUIRED FOR ONE SQUARE OF ROOF.

1 Square = 100 Square Feet.

Dimensions in inches	12×48	15×60	20×100	94×156
Thicknesses in inches	$3\frac{1}{6}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$
Area in square feet	3.997	6.246	13.880	101.768
Weight in lbs. per square of roof	250	350	500	700

In the above table no allowance is made for lap.

DIMENSIONS, ETC., OF STANDARD PIPE FLANGES.

A. S. M. E. & M. S. F. A.

July 14, 1894.

100 Pounds Pressure per Square Inch.

Pipe Diam., Inches.	Flange.		Radius of Bolts, Inches.	Bolts.		
	Diameter, Inches.	Thickness, Inches.		Number.	Size, Inches.	Stress per Sq. In.
2	6	$\frac{5}{8}$	$2\frac{3}{8}$	4	$\frac{1}{2}$	628
$2\frac{1}{2}$	7	$\frac{11}{16}$	$2\frac{5}{8}$	4	$\frac{1}{2}$	980
3	$7\frac{1}{2}$	$\frac{3}{4}$	3	4	$\frac{1}{2}$	1400
$3\frac{1}{2}$	$8\frac{1}{2}$	$\frac{13}{16}$	$3\frac{1}{4}$	4	$\frac{1}{2}$	1924
4	9	$\frac{15}{16}$	$3\frac{5}{8}$	4	$\frac{5}{8}$	1570
$4\frac{1}{2}$	$9\frac{1}{4}$	$\frac{15}{16}$	$3\frac{7}{8}$	8	$\frac{5}{8}$	984
5	10	$\frac{15}{16}$	$4\frac{1}{4}$	8	$\frac{5}{8}$	1215
6	11	1	$4\frac{13}{16}$	8	$\frac{5}{8}$	1749
7	$12\frac{1}{2}$	$1\frac{1}{16}$	$5\frac{3}{8}$	8	$\frac{5}{8}$	2381
8	$13\frac{1}{2}$	$1\frac{1}{8}$	$5\frac{7}{8}$	8	$\frac{5}{8}$	3110
9	15	$1\frac{1}{8}$	$6\frac{1}{2}$	12	$\frac{5}{8}$	2624
10	16	$1\frac{3}{16}$	$7\frac{1}{8}$	12	$\frac{3}{4}$	2167
12	19	$1\frac{1}{4}$	$8\frac{1}{4}$	12	$\frac{3}{4}$	3118
14	21	$1\frac{3}{8}$	$9\frac{3}{8}$	12	$\frac{7}{8}$	3065
15	$22\frac{1}{4}$	$1\frac{3}{8}$	10	16	$\frac{7}{8}$	2636
16	$23\frac{1}{2}$	$1\frac{7}{16}$	$10\frac{5}{8}$	16	$\frac{7}{8}$	3000
18	25	$1\frac{9}{16}$	$11\frac{3}{8}$	16	1	2891
20	$27\frac{1}{2}$	$1\frac{11}{16}$	$12\frac{1}{2}$	20	1	2855
22	$29\frac{1}{2}$	$1\frac{13}{16}$	$13\frac{5}{8}$	20	1	3455
24	$31\frac{1}{2}$	$1\frac{1}{4}$	$14\frac{5}{8}$.	20	1	4112
26	$33\frac{3}{4}$	$1\frac{7}{8}$	$15\frac{5}{8}$	24	1	4022
28	36	$1\frac{15}{16}$	$16\frac{3}{4}$	28	1	4000
30	38	$1\frac{1}{2}$	$17\frac{3}{4}$	28	$1\frac{1}{8}$	3643
36	$44\frac{1}{2}$	$1\frac{3}{4}$	21	32	$1\frac{1}{8}$	4627
42	51	$1\frac{7}{8}$	$24\frac{1}{4}$	36	$1\frac{1}{4}$	6205
48	$57\frac{1}{2}$	2	$27\frac{3}{8}$	44	$1\frac{3}{8}$	3900

DIMENSIONS, ETC., OF STANDARD PIPE FLANGES.—*Continued.*

200 Pounds Pressure per Square Inch.

Pipe Diam., Inches.	Flange.		Radius of Bolts, Inches.	Bolts.		
	Diameter, Inches.	Thickness, Inches.		Number.	Size, Inches.	Stress per Sq. In.
2	6	$\frac{5}{8}$	$2\frac{3}{8}$	4	$\frac{5}{8}$	777
$2\frac{1}{2}$	7	$\frac{11}{16}$	$2\frac{5}{8}$	4	$\frac{5}{8}$	1214
3	$7\frac{1}{2}$	$\frac{3}{4}$	3	4	$\frac{5}{8}$	1749
$3\frac{1}{2}$	$8\frac{1}{2}$	$\frac{13}{16}$	$3\frac{1}{4}$	4	$\frac{5}{8}$	2381
4	9	$\frac{15}{16}$	$3\frac{5}{8}$	4	$\frac{3}{4}$	2080
$4\frac{1}{2}$	$9\frac{1}{4}$	$\frac{15}{16}$	$3\frac{7}{8}$	8	$\frac{3}{4}$	1316
5	10	$\frac{15}{16}$	$4\frac{1}{4}$	8	$\frac{3}{4}$	1625
6	11	1	$4\frac{13}{16}$	8	$\frac{3}{4}$	2340
7	$12\frac{1}{2}$	$1\frac{1}{16}$	$5\frac{3}{8}$	8	$\frac{3}{4}$	3185
8	$13\frac{1}{2}$	$1\frac{1}{8}$	$5\frac{7}{8}$	8	$\frac{3}{4}$	4165
9	15	$1\frac{1}{8}$	$6\frac{1}{2}$	12	$\frac{3}{4}$	3510
10	16	$1\frac{3}{16}$	$7\frac{1}{8}$	12	$\frac{7}{8}$	3142
12	19	$1\frac{1}{4}$	$8\frac{1}{4}$	12	$\frac{7}{8}$	4520
14	21	$1\frac{3}{8}$	$9\frac{3}{8}$	12	1	2332
15	$22\frac{1}{4}$	$1\frac{3}{8}$	10	16	1	4017
16	$23\frac{1}{2}$	$1\frac{7}{16}$	$10\frac{5}{8}$	16	1	4570
18	25	$1\frac{9}{16}$	$11\frac{3}{8}$	16	$1\frac{1}{8}$	4582
20	$27\frac{1}{2}$	$1\frac{11}{16}$	$12\frac{1}{2}$	20	$1\frac{1}{8}$	4526
22	$29\frac{1}{2}$	$1\frac{13}{16}$	$13\frac{5}{8}$	20	$1\frac{1}{4}$	4266
24	32	$1\frac{7}{8}$	$14\frac{3}{4}$	20	$1\frac{1}{4}$	5076
26	$34\frac{1}{4}$	2	$15\frac{7}{8}$	24	$1\frac{1}{4}$	5000
28	$36\frac{1}{2}$	$2\frac{1}{16}$	17	28	$1\frac{1}{4}$	4926
30	$38\frac{3}{4}$	$2\frac{1}{8}$	18	28	$1\frac{3}{8}$	4126
36	$45\frac{3}{4}$	$2\frac{3}{8}$	$21\frac{3}{8}$	32	$1\frac{3}{8}$	6000
42	$52\frac{3}{4}$	$2\frac{5}{8}$	$24\frac{3}{4}$	36	$1\frac{1}{2}$	5949
48	$59\frac{1}{2}$	$2\frac{3}{4}$	28	44	$1\frac{1}{2}$	6350

BRASS TUBING.

Brass tubing is usually sold in 12-foot lengths, but can be furnished in 16-foot lengths if ordered from the mill.

Annealed tubing is best for bending purposes, and the Half Hard is best adapted for general use.

FLOW OF WATER IN HOUSE-SERVICE PIPES.

(Thomson Meter Co.)

Condition of Discharge.	Pressure in Main, Lbs. per Sq. In.	Discharge in Cubic Feet per Minute from the Pipe. Nominal Diameters of Iron or Lead Service-pipe in Inches.								
		½	⅝	¾	1	1½	2	3	4	6
Through 35 feet of service-pipe, no back pressure.	30	1.10	1.92	3.01	6.13	16.58	33.34	88.16	173.85	444.63
	40	1.27	2.22	3.48	7.08	19.14	38.50	101.80	200.75	513.42
	50	1.42	2.48	3.89	7.92	21.40	43.04	113.82	224.44	574.02
	60	1.56	2.71	4.26	8.67	23.44	47.15	124.68	245.87	628.81
	75	1.74	3.03	4.77	9.70	26.21	52.71	139.39	274.89	703.03
	100	2.01	3.50	5.50	11.20	30.27	60.87	160.96	317.41	811.79
	130	2.29	3.99	6.28	12.77	34.51	69.40	183.52	361.91	925.58
Through 100 feet of service-pipe, no back pressure.	30	0.66	1.16	1.84	3.78	10.40	21.30	58.19	118.13	317.23
	40	0.77	1.34	2.12	4.36	12.01	24.59	67.19	136.41	366.30
	50	0.86	1.50	2.37	4.88	13.43	27.50	75.13	152.51	409.54
	60	0.94	1.65	2.60	5.34	14.71	30.12	82.30	167.06	448.63
	75	1.05	1.84	2.91	5.97	16.45	33.68	92.01	186.78	501.58
	100	1.22	2.13	3.36	6.90	18.99	38.89	106.24	215.68	579.18
	130	1.39	2.42	3.83	7.86	21.66	44.34	121.14	245.91	660.36
Through 100 feet of service-pipe and 15 feet vertical rise.	30	0.55	0.96	1.52	3.11	8.57	17.55	47.90	97.17	260.56
	40	0.66	1.15	1.81	3.72	10.24	20.95	57.20	116.01	311.09
	50	0.75	1.31	2.06	4.24	11.67	23.87	65.18	132.20	354.49
	60	0.83	1.45	2.29	4.70	12.94	26.48	72.28	146.61	393.13
	75	0.94	1.64	2.59	5.32	14.64	29.96	81.79	165.90	444.85
	100	1.10	1.92	3.02	6.21	17.10	35.00	95.55	193.82	519.72
	130	1.26	2.20	3.48	7.14	19.66	40.23	109.82	222.75	597.31
Through 100 feet of service-pipe and 30 feet vertical rise.	30	0.44	0.77	1.22	2.50	6.80	14.11	38.63	78.54	211.54
	40	0.55	0.97	1.53	3.15	8.68	17.79	48.68	98.98	266.59
	50	0.65	1.14	1.79	3.69	10.16	20.82	56.98	115.87	312.08
	60	0.73	1.28	2.02	4.15	11.45	23.47	64.22	130.59	351.73
	75	0.84	1.47	2.32	4.77	13.15	26.95	73.76	149.99	403.98
	100	1.00	1.74	2.75	5.65	15.58	31.93	87.38	177.67	478.55
	130	1.15	2.02	3.19	6.55	18.07	37.02	101.33	206.04	554.96

TEMPERATURES.

The following table affords a somewhat rough method of estimating high temperature.

	Centigrade Degrees.	Fahrenheit Degrees.
Just glowing in the dark	525	977
Dark red	700	1252
Cherry red	908	1666
Bright cherry red	1000	1832
Orange	1150	2102
White	1300	2372
Dazzling white	1500	2732

LINEAR EXPANSION OF SUBSTANCES BY HEAT.

To find the increase in the length of a bar of any material due to an increase of temperature, multiply the number of degrees of increase of temperature by the coefficient for 100 degrees and by the length of the bar and divide by 100.

Name of Substance.	Coefficient for 100° Fahrenheit.	Coefficient for 180° Fahrenheit, or 100 Centigrade.
Baywood (in the direction of the grain, dry)	.00026 to .00031	.00046 to .00057
Brass (cast)	.00104	.00188
" (wire)	.00107	.00193
Brick (fire)	.0003	.0005
Cement (Roman)	.0008	.0014
Copper	.0009	.0017
Deal (in the direction of the grain, dry)	.00024	.00044
Glass (English flint)	.00045	.00081
" (French white lead)	.00048	.00087
Gold	.0008	.0015
Granite (average)	.00047	.00085
Iron (cast)	.0006	.0011
" (soft forged)	.0007	.0012
" (wire)	.0008	.0014
Lead	.0016	.0029
Marble (Carrara)	.00036 to .0006	.00065 to .0011
Mercury	.0033	.0060
Platinum	.0005	.0009
Sandstone	.0005 to .0007	.0009 to .0012
Silver	.0011	.002
Slate (Wales)	.0006	.001
Water (varies considerably with the temperature)	.0086	.0155
Tin	.0003	.0069
Zinc	.0004	.0088

NUMBER OF U. S. GALLONS IN RECTANGULAR TANKS.

For One Foot in Depth.

Width in Feet.	Length of Tank in Feet.										
	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
2	29.92	37.40	44.88	52.36	59.84	67.32	74.81	82.29	89.77	97.25	104.73
2.5	.....	46.75	56.10	65.45	74.80	84.16	93.51	102.86	112.21	121.56	130.91
3	.....	.....	67.32	78.54	89.77	100.99	112.21	123.43	134.65	145.87	157.09
3.5	.....	.....	.....	91.64	104.73	117.82	130.91	144.00	157.09	170.18	183.27
4	.....	.....	.....	.....	119.69	134.65	149.61	164.57	179.53	194.49	209.45
4.5	.....	.....	.....	.....	.....	151.48	168.31	185.14	201.97	218.80	235.63
5	.....	.....	.....	.....	.....	.....	187.01	205.71	224.41	243.11	261.82
5.5	.....	.....	.....	.....	.....	.....	.....	226.28	246.86	267.43	288.00
6	.....	.....	.....	.....	.....	.....	.....	.....	269.30	291.74	314.18
6.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	316.05	340.36
7.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	366.54

Width in Feet.	Length of Tank in Feet.									
	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12
2	112.21	119.69	127.17	134.65	142.13	149.61	157.09	164.57	172.05	179.53
2.5	140.26	149.61	158.96	168.31	177.66	187.01	196.36	205.71	215.06	224.41
3	168.31	179.53	190.75	202.97	213.19	224.41	235.63	246.86	258.07	269.30
3.5	196.36	209.45	222.54	235.63	248.73	261.82	274.90	288.00	301.09	314.18
4	224.41	239.37	254.34	269.30	284.26	299.22	314.18	329.14	344.10	359.06
4.5	252.47	269.30	286.13	302.96	319.79	336.62	353.45	370.28	387.11	403.94
5	280.52	299.22	317.92	336.62	355.32	374.03	392.72	411.43	430.13	448.83
5.5	308.57	329.14	349.71	370.28	390.85	411.43	432.00	452.57	473.14	493.71
6	336.62	359.06	381.50	403.94	426.39	448.83	471.27	493.71	516.15	538.59
6.5	364.67	388.98	413.30	437.60	461.92	486.23	510.54	534.85	559.16	583.47
7	392.72	418.91	445.09	471.27	497.45	523.64	549.81	575.99	602.18	628.36
7.5	420.78	448.83	476.88	504.93	532.98	561.04	589.08	617.14	645.19	673.24
8	.....	478.75	508.67	538.59	568.51	598.44	628.36	658.28	688.20	718.12
8.5	.....	.....	540.46	572.25	604.05	635.84	667.63	699.42	731.21	763.00
9	.....	.....	.....	605.92	639.58	673.25	706.90	740.56	774.23	807.89
9.5	.....	.....	.....	.....	675.11	710.65	746.17	781.71	817.24	852.77
10	.....	.....	.....	.....	.....	748.05	785.45	822.86	860.26	897.66
10.5	.....	.....	.....	.....	.....	.....	824.73	864.00	903.26	942.56
11	.....	.....	.....	.....	.....	.....	.....	905.14	946.27	987.43
11.5	.....	.....	.....	.....	.....	.....	.....	.....	989.29	1032.3
12	.....	.....	.....	.....	.....	.....	.....	.....	.....	1077.2

Example. — To find number of gallons in a rectangular tank that is 7.5 feet by 10 feet, the water being 4 feet deep: Look in extreme left-hand column for 7.5, and opposite to this in column headed 10 read 561.04, which being multiplied by 4, the depth of water in the tank, gives 2244.2, the number of gallons required.

WEIGHT OF ROUGH GLASS PER SQUARE FOOT.

Thickness, inches...............	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1
Weight, pounds..................	2	$2\frac{1}{2}$	$3\frac{1}{2}$	5	7	$8\frac{1}{2}$	10	$12\frac{1}{2}$

NUMBER OF GALLONS IN ROUND CISTERNS AND TANKS.

Depth in Feet.	Diameter in Feet. 5	6	7	8	9	10	11	12
5	735	1,060	1,440	1,875	2,380	2,925	3,550	4,237
6	881	1,270	1,728	2,250	2,855	3,510	4,260	5,084
7	1,028	1,480	2,016	2,625	3,330	4,095	4,970	5,931
8	1,175	1,690	2,304	3,000	3,805	4,680	5,680	6,778
9	1,322	1,900	2,592	3,375	4,280	5,265	6,390	7,625
10	1,469	2,110	2,880	3,750	4,755	5,850	7,100	8,472
11	1,616	2,320	3,168	4,125	5,250	6,435	7,810	9,319
12	1,762	2,530	3,456	4,500	5,705	7,020	8,520	10,166
13	1,909	2,740	3,744	4,875	6,180	7,605	9,230	11,013
14	2,056	2,950	4,032	5,250	6,655	8,190	9,940	11,860
15	2,203	3,160	4,320	5,625	7,130	8,775	10,650	12,707
16	2,356	3,370	4,608	6,000	7,605	9,360	11,360	13,554
17	2,497	3,580	4,896	6,375	8,080	9,945	12,070	14,401
18	2,644	3,790	5,184	6,750	8,535	10,530	12,780	15,245
19	2,791	4,000	5,472	7,125	9,010	11,115	13,490	16,098
20	2,938	4,210	5,760	7,500	9,490	11,700	14,200	16,942

Depth in Feet.	Diameter in Feet. 13	14	15	16	18	20	22	24
5	4,960	5,765	6,698	7,520	9,516	11,750	14,215	16,918
6	5,952	6,918	8,038	9,024	11,419	14,100	17,059	20,302
7	6,944	8,071	9,378	10,528	13,322	16,450	19,902	23,680
8	7,936	9,224	10,718	12,032	15,225	18,800	22,745	27,070
9	8,928	10,377	12,058	13,536	17,128	21,150	25,588	30,454
10	9,920	11,530	13,398	15,040	19,031	23,500	28,431	33,838
11	10,913	12,683	14,738	16,544	20,934	25,850	31,274	37,222
12	11,904	13,836	16,078	18,048	22,837	28,200	34,117	40,606
13	12,896	14,989	17,418	19,552	24,740	30,550	36,960	43,990
14	13,888	16,142	18,758	21,056	26,643	32,900	39,803	47,374
15	14,880	17,295	20,098	22,260	28,546	35,250	42,646	50,758
16	15,872	18,448	21,438	26,064	30,449	37,600	45,489	54,142
17	16,864	19,601	22,778	25,568	32,352	39,950	48,332	57,520
18	17,856	20,754	24,118	27,072	34,255	42,300	51,175	60,910
19	18,848	21,907	25,458	28,576	36,158	44,650	54,018	64,294
20	19,840	23,060	26,798	30,080	38,062	47,000	56,861	67,678

To find the number of gallons in a tank of unequal diameter multiply the inside bottom diameter in inches by the inside top diameter in inches, then this product by 34: point off four figures and the result will be the average number of gallons to one inch in depth of the tank.

Size of Conductor Pipes.

The size of conductor pipe necessary to drain gutters is as follows: —

$3\frac{1}{2}$	in.	Trough,	up to 12	ft.	long;	use 2	in.	Conductor Pipe
$3\frac{1}{2}$	"	"	12 to 25	"	"	" 3	"	" "
4	"	"	25 to 35	"	"	" 3	"	" "
5	"	"	35 to 45	"	"	" 4	"	" "
6	"	"	45 to 55	"	"	" 5	"	" "
7	"	"	55 to 65	"	"	" 6	"	" "
8	"	"	65 to 75	"	"	" 7	"	" "

Capacity of Boxes.

Liquid.	A box 24 × 24 × 14.7 inches will hold a barrel of $31\frac{1}{2}$ gallons.
	A box 15 × 14 × 11 inches will hold 10 gallons.
	A box $8\frac{1}{4}$ × 7 × 4 inches will hold a gallon.
	A box 4 × 4 × 3.6 inches will hold a quart.
Dry.	A box 24 × 28 × 16 inches will hold 5 bushels.
	A box 16 × 12 × 11.2 inches will hold a bushel.
	A box 12 × 11.2 × 8 inches will hold a half-bushel.
	A box 7 × 6.4 × 12 inches will hold a peck.
	A box 8.4 × 8 × 4 inches will hold a half-peck, or 4 dry quarts.
	A box 6 × $5\frac{3}{5}$ × 4 inches will hold a half-gallon.
	A box 4 × 4 × $2\frac{1}{10}$ inches will hold a pint.

Capacity of Expansion Tanks.

Size, Inches.	Capacity, Gallons.	Size, Inches.	Capacity, Gallons.
12×20	10	30×120	372
12×24	12	36×48	212
12×30	15	36×60	265
12×36	18	36×72	318
14×30	20	36×84	371
14×36	24	36×96	424
16×30	26	36×108	477
16×36	32	36×120	530
24×48	94	36×144	636
24×60	117	42×60	360
24×72	141	42×72	432
30×48	147	42×84	504
30×60	184	42×96	572
30×72	221	42×108	644
30×84	258	42×120	716
30×96	294	42×144	860
30×108	335		

DIMENSIONS FOR LIQUID MEASURES.

Size.	Diameter of Top, Inches.	Diameter of Bottom, Inches.	Height, Inches.
5-gallon	8	13½	12⅜
3-gallon	7	11½	10⅛
2-gallon	6	10½	8⅜
1-gallon	3¾	8¾	7½
1-quart	2½	5⅛	4⅞
1-pint	2	4	4

A gill contains 7.22 cubic inches.
A pint " 28.87 " "
A quart " 57.75 " "
A gallon " 231 " "

DIMENSIONS OF SQUARE OR KITCHEN SINKS.

Length.	Width.	Depth.	Length.	Width.	Depth.
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
16	12	6	30	12	6
16	16	6	30	16	6
18	12	6	30	18	6
18	16	6	30	20	6
18	18	6	32	18	6
20	12	6	32	21	6
20	14	6	34	20	6
20	16	6	36	16	6
20	20	6	36	18	6
22	14	6	36	20	6
23	15	6	36	21	6
24	14	6	36	22	6
24	15	6	38	19	6
24	16	6	38	20	6
24	17	6	40	20	6
24	18	6	41	22	6
24	20	6	42	18	6
25½	15½	6	42	20	6
25	17	6	42	22	6
27	15	6	48	20	6
28	16	6	48	22	6
28	17	6	48	23	6
28	20	6	48	24	6

DIMENSIONS OF LARGE OR HOTEL SINKS.

Length.	Width.	Depth.	Length.	Width.	Depth.
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
50	24	6½	72	24	6
60	20	6	76	22	7
60	24	6	84	24	6
62	22	8	96	24	6
62	26	8	108	24	6
72	20	6	120	24	6

SIZE AND CAPACITY OF ROUND END STOCK WATERING AND RESERVOIR TANKS.

Length.	Width.	Height.	Capacity.	Weight.
4 ft.	2 ft.	2 ft.	3¾ bbls.	70 lbs.
5 ft.	2 ft.	2 ft.	4¾ bbls.	86 lbs.
6 ft.	2 ft.	2 ft.	5¾ bbls.	103 lbs.
7 ft.	2 ft.	2 ft.	6½ bbls.	119 lbs.
8 ft.	2 ft.	2 ft.	7½ bbls.	137 lbs.
8 ft.	2 ft.	2½ ft.	9½ bbls.	150 lbs.
8 ft.	2½ ft.	2 ft.	9½ bbls.	144 lbs.
8 ft.	2½ ft.	2½ ft.	12 bbls.	150 lbs.
8 ft.	3 ft.	2 ft.	11½ bbls.	152 lbs.
8 ft.	3 ft.	2½ ft.	14 bbls.	166 lbs.
8 ft.	4 ft.	2 ft.	15 bbls.	173 lbs.
8 ft.	4 ft.	2½ ft.	17 bbls.	190 lbs.
8 ft.	4 ft.	3 ft.	23 bbls.	215 lbs.
8 ft.	6 ft.	2 ft.	23½ bbls.	240 lbs.
10 ft.	2 ft.	2 ft.	9½ bbls.	160 lbs.
10 ft.	3 ft.	2 ft.	14 bbls.	185 lbs.
10 ft.	3 ft.	2½ ft.	18 bbls.	210 lbs.
10 ft.	3 ft.	3 ft.	21 bbls.	235 lbs.
10 ft.	4 ft.	2 ft.	19 bbls.	210 lbs.
10 ft.	4 ft.	2½ ft.	24 bbls.	247 lbs.
10 ft.	4 ft.	3 ft.	29 bbls.	277 lbs.
10 ft.	6 ft.	2 ft.	28½ bbls.	285 lbs.
10 ft.	4 ft.	5 ft.	47 bbls.	440 lbs.
10 ft.	6 ft.	4 ft.	56 bbls.	434 lbs.
16 ft.	4 ft.	2 ft.	30 bbls.	372 lbs.
16 ft.	5 ft.	2 ft.	38 bbls.	412 lbs.

SIZE AND CAPACITY OF ROUND END OBLONG TANKS.

Length.	Width.	Height.	Capacity.	Weight.
4 ft.	18 in.	12 in.	40 gals.	50 lbs.
4 ft.	24 in.	12 in.	50 gals.	55 lbs.
6 ft.	24 in.	12 in.	80 gals.	80 lbs.
6 ft.	24 in.	18 in.	120 gals.	90 lbs.
8 ft.	18 in.	12 in.	80 gals.	90 lbs.
8 ft.	24 in.	12 in.	110 gals.	100 lbs.
8 ft.	24 in.	18 in.	165 gals.	110 lbs.
10 ft.	24 in.	12 in.	140 gals.	120 lbs.
10 ft.	24 in.	18 in.	210 gals.	140 lbs.

SIZE AND CAPACITY OF RECTANGULAR TANKS IN BARRELS. (1 bbl.= 31·5 gallons.)

Width.	Height.	Length.	Capacity.
2 feet	2 feet	4 feet	3.8 barrels
2 feet	2 feet	6 feet	5.7 barrels
2 feet	2 feet	8 feet	7.6 barrels
2½ feet	2 feet	8 feet	9½ barrels
3 feet	2 feet	8 feet	11.4 barrels
4 feet	2 feet	8 feet	15.2 barrels
3 feet	2 feet	10 feet	14.2 barrels
4 feet	2 feet	10 feet	19 barrels
4 feet	2 feet	16 feet	30.4 barrels

Bursting Strength of Brass and Copper Tubes.

To estimate the safe limit of bursting pressure for seamless brass and copper tubing in pounds per square inch:

FIRST — Ascertain the tensile strength of the metal in the tube, which will vary according to the quality and temper.

SECOND. — Multiply the tensile strength by the thickness of the metal in inches, or decimal parts of an inch.

THIRD. — Divide by the radius (one-half of the diameter) expressed in inches, and the result shows the pressure in pounds per square inch.

If a safety factor of six (6) is allowed, divide the above result by six (6). Example: A tube 4 inches outside diameter, No.

8 B. &. S. Gauge, made of Brass, which has a tensile strength of 40,000 pounds per square inch, shows 428 pounds pressure per square inch as follows:

40,000 lbs. per square inch.
.1284 or No. 8 B. &. S. thick.

½ diam. of 4 in. Tube = 2 in) 5136.0000

Factor of safety, 6) 2568.0000

428 lbs. pressure per sq. in.

Brass in tubes has a maximum tensile strength of 40.000 pounds per square inch.

Copper in tubes has a maximum tensile strength of 30.000 pounds per square inch.

STRENGTH OF WROUGHT IRON BOLTS.*

(Computed by A. F. Nagle.)

Diameter of Bolt, Inches.	Number of Threads.	Diameter of Bottom of Thread, Inches.	Area at Bottom of Thread, Square Inches.	Stress upon Bolt upon Basis of Working Strength of					Probable Breaking Load.
				3000 Lbs. per Sq. Inch.	4000 Lbs. per Sq. Inch.	5000 Lbs. per Sq. Inch.	7000 Lbs. per Sq. Inch.	10,000 Lbs. per Sq. Inch.	
				lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
½	13	.38	.12	350	460	580	810	1160	5800
9/16	12	.44	.15	450	600	750	1050	1500	7500
⅝	11	.49	.19	560	750	930	1310	1870	9000
¾	10	.60	.28	750	1130	1410	1980	2830	14000
⅞	9	.71	.39	1180	1570	1970	2760	3940	19000
1	8	.81	.52	1550	2070	2600	3630	5180	25000
1⅛	7	.91	.65	1950	2600	3250	4560	6510	30000
1¼	7	1.04	.84	2520	3360	4200	5900	8410	39000
1⅜	6	1.12	1.00	3000	4000	5000	7000	10000	46000
1½	6	1.25	1.23	3680	4910	6140	8600	12280	56000
1⅝	5½	1.35	1.44	4300	5740	7180	10000	14360	65000
1¾	5	1.45	1.65	4950	6600	8250	11560	16510	74000
1⅞	5	1.57	1.95	5840	7800	9800	13640	19500	85000
2	4½	1.66	2.18	6540	8720	10900	15260	21800	95000
2¼	4½	1.92	2.88	8650	11530	14400	20180	28800	125000
2½	4	2.12	3.55	10640	14200	17730	24830	35500	150000
2¾	4	2.37	4.43	13290	17720	22150	31000	44300	186000
3	3½	2.57	5.20	15580	20770	26000	36360	52000	213000
3½	3¼	3.04	7.25	21760	29000	36260	50760	72500	290000
4	3	3.50	9.62	28860	38500	48100	67350	96200	385000

* *National Tube Co. Pocket Book.*

When the greatest load that has to be sustained by a bolt is known, and the working strength per square inch of the material constituting it is determined, look in the proper column for the given load. Should the load sought be not found, then take the load next larger as found in the column, and opposite to it in the first column read the required size of bolt.

NAME OF ALLOYS OR COMPOSITION OF METALS.

Name of Metal.	Alloys.
Aluminium bronze	Copper and Aluminium
Bell metal	Copper and Tin
Brass	Copper and Zinc
Britannia metal	Tin and Antimony
Bronze	Copper and Tin
Dutch metal	Copper and Zinc
German Silver	Copper, Nickel and Zinc
Gold currency	Gold and Copper
Gun metal	Copper and Tin
Mosaic gold	Gold, Silver and Copper
Ormolu	Copper and Zinc
Pewter	Tin and Lead
Silver currency	Silver and Copper
Shot	Lead and Arsenic
Solder	Lead and Tin
Stereotype metal	Lead, Antimony and Bismuth
Type metal	Lead and Antimony (also copper at times)

Metal combine with Chlorine and produce Chlorides.
Metal combine with Sulphur and produce Sulphides.
Metal combine with Oxygen and produce Oxides.

PRESSURE OF ATMOSPHERE.

1 Atmosphere, = pressure per sq. inch of the atmosphere at sea level, which is 14.7 pounds per sq. inch; corresponding to a column of water 34 feet high, or a column of mercury about 30 inches high.

WEIGHT AND STRENGTH OF RIVETED HYDRAULIC PIPE.

Showing size and weight, with safe head for various sizes of double riveted Sheet Steel pipe.

(Pelton Water Wheel Co.)

Diameter of Pipe in Inches.	Thickness of Material U. S. Standard Gauge	Equivalent Thickness in Inches.	Head in Feet Pipe will Safely Stand.	Weight per Lineal Foot in Pounds.	Diameter of Pipe in Inches.	Thickness of Material U. S. Standard Gauge	Equivalent Thickness in Inches.	Head in Feet Pipe will Safely Stand.	Weight per Lineal Foot in Pounds.
3	18	.05	810	2.25	12	16	.062	252	10.00
4	18	.05	607	3.00	12	14	.078	316	12.25
4	16	.062	760	3.75	12	12	.109	442	17.00
					12	11	.125	506	19.50
5	18	.05	485	3.75	12	10	.14	567	21.75
5	16	.062	605	4.50					
5	14	.078	757	5.75	13	16	.062	233	10.50
					13	14	.078	291	13.00
6	18	.05	405	4.25	13	12	.109	407	18.00
6	16	.062	505	5.25	13	11	.125	467	20.50
6	14	.078	630	6.50	13	10	.14	522	23.00
7	18	.05	346	4.75	14	16	.062	216	11.25
7	16	.062	433	6.00	14	14	.078	271	14.00
7	14	.078	540	7.50	14	12	.109	378	19.50
					14	11	.125	433	22.25
8	16	.062	378	7.00	14	10	.14	485	25.00
8	14	.078	472	8.75					
8	12	.109	660	12.00	15	16	.062	202	11.75
					15	14	.078	252	14.75
9	16	.062	336	7.50	15	12	.109	352	20.50
9	14	.078	420	9.25	15	11	.125	405	23.25
9	12	.109	587	12.75	15	10	.14	453	26.00
10	16	.062	307	8.25	16	14	.078	237	16.00
10	14	.078	378	10.25	16	12	.109	332	22.25
10	12	.109	530	14.25	16	11	.125	379	24.50
10	11	.125	607	16.25	16	10	.14	425	28.50
10	10	.14	680	18.25					
					18	14	.078	210	18.50
11	16	.062	275	9.00	18	12	.109	295	25.25
11	14	.078	344	11.00	18	11	.125	337	29.00
11	12	.109	480	15.25	18	10	.14	378	32.50
11	11	.125	553	17.50	18	8	.171	460	40.00
11	10	.14	617	19.50					

WEIGHT AND STRENGTH OF RIVETED HYDRAULIC PIPE.—*Continued.*

Showing size and weight with safe head for various sizes of double riveted Sheet Steel pipe.

Diameter of pipe in Inches.	Thickness of Material U. S. Standard Gauge	Equivalent Thickness in Inches.	Head in Feet Pipe will Safely Stand.	Weight per Lineal Foot in Pounds.	Diameter of Pipe in Inches.	Thickness of Material U. S. Standard Gauge.	Equivalent Thickness in Inches.	Head in Feet Pipe will Safely Stand.	Weight per Lineal Foot in Pounds.
20	14	.078	189	19.75	28	12	.109	188	38.00
20	12	.109	265	27.50	28	11	.125	216	42.25
20	11	.125	304	31.50	28	10	.14	242	47.50
20	10	.14	340	35.00	28	8	.171	295	58.00
20	8	.171	415	45.50	28	6	.20	346	69.00
22	14	.078	172	22.00	30	11	.125	202	45.00
22	12	.109	240	30.50	30	10	.14	226	50.50
22	11	.125	276	34.50	30	8	.171	276	61.75
22	10	.14	309	39.00	30	6	.20	323	73.00
22	8	.171	376	50.00	30	$\frac{1}{4}$	.25	404	90.00
24	12	.109	220	32.00	36	10	.14	189	60.50
24	11	.125	253	37.50	36	$\frac{3}{16}$	.187	252	81.00
24	10	.14	283	42.00	36	$\frac{1}{4}$	.25	337	109.00
24	8	.171	346	50.00	36	$\frac{5}{16}$	.312	420	135.00
24	6	.20	405	59.00					
					40	$\frac{3}{16}$	.187	226	90.00
26	12	.109	203	35.50	40	$\frac{1}{4}$	.25	303	120.00
26	11	.125	233	39.50	40	$\frac{5}{16}$	.312	378	150.00
26	10	.14	261	44.25	40	$\frac{3}{8}$	.375	455	180.00
26	8	.171	319	54.00					
26	6	.20	373	64.00					

SIZES OF PLUMBERS' TOOL BAGS.

Plumbers' tool bags are now manufactured and can be purchased at the leading hardware stores; they are made of heavy canvas in the following sizes:

No. 1 $16'' \times 21''$.
No. 2 $22'' \times 19''$.
No. 3 $17'' \times 20''$.

WEIGHT AND STRENGTH OF SPIRAL RIVETED PIPE.

STANDARD PLAIN AND PRESSURE PIPE.

(*Abendroth and Root Manufacturing Co.*)

Diameter in Inches.	Thickness, B. W. G.	Approximate Weight in Lbs. per Foot.	Approximate Bursting Pressure in Lbs. per Square Inch.	Weight Each Flange Attached.
3	No. 20	2	900	3
3½	"	2¼	820	3½
4	"	2½	700	3¾
5	"	3½	550	5
6	No. 18	4¼	700	6¼
7	"	5	600	8
8	"	6	500	9¼
9	"	6½	450	12¼
10	No. 16	9½	500	15
11	"	10¼	450	16
12	"	12¼	400	17½
13	"	13	380	18¾
14	No. 14	17½	470	21
15	"	19½	450	23
16	"	20½	400	34
18	"	25	370	40
20	"	28½	325	44
22	No. 12	33	365	66
24	"	40	335	71
26	"	66	300	145
28	No. 10	....	....	168
30	"	....	....	178

WEIGHT AND STRENGTH OF SPIRAL RIVETED PIPE. — *Continued.*

EXTRA HEAVY PLAIN AND PRESSURE PIPE.

Diameter in Inches.	Thickness, B. W. G.	Approximate Weight in Lbs. per Foot.	Approximate Bursting Pressure in Lbs. per Square Inch.
3	No. 18	2½	1,300
3½	"	3	1,275
4	No. 16	4½	1,250
5	"	5¼	1,000
6	"	5⅔	800
7	"	6½	700
8	"	7¾	600
9	"	8¾	550
10	No. 14	11¾	650
11	"	13	600
12	"	15	550
13	"	16¼	500
14	No. 12	22½	570
15	"	24½	530
16	"	25½	500
18	"	31	440
20	"	35½	400
22	No. 10	44	450
24	"	52	400
26	"	62	350

THICKNESS AND WEIGHT OF RUBBER MATTING.

Rubber matting such as is used for floors of kitchens, bath rooms, etc., is made ⅛ inch thick and weighs about 8 lbs. per square yard; this matting is made 36 inches wide and any length.

RIVETED STEEL PIPE LINES IN UNITED STATES.

A partial list of riveted steel pipe lines in the United States was included in a recent special report made by Major Cassius E. Gillette, while chief of the Philadelphia Bureau of Filtration, as follows:

Year.	Location.	Size, Inches.	Length, Approximate, Feet.
1871	First Pittsburg, Pa., Rising Main	50	2,900
1891	East Jersey Water Co.	48	116,000
1891	East Jersey Water Co., Belleville.	36	26,000
1892	Syracuse, N. Y.	54	6,500
1893	(2) Rochester, N. Y.	38	142,000
1894	Second Pittsburg, Rising Main	50	1,600
1894	Portland, Ore.	33 and 42	126,000
1895	Allegheny City, Pa	60	50,000
1895	East Jersey Water Co., Kearney, N. J.	42	8,800
1896	East Jersey Water Co., Newark, N. J.	48	26,400
1896	East Jersey Water Co.	42	89,700
1896	New Bedford, Mass.	48	42,500
1896	Duluth, Minn.	42	15,000
1896	Ogden, Utah	72	5,000
1897	Minneapolis, Minn.	50	34,400
1897	Passaic Water Co., N. J.	42	21,000
1898	Albany, N. Y.	48	8,000
1899	Seattle, Wash.	42	32,400
1899	East Jersey Water Co	51	47,500
1900	Utica Power Co., Utica, N. Y.	84	1,000
1899	Third Rising Main, Pittsburg, Pa.	48	4,400
1901	Atlantic City, N. J.	30	27,000
1901	Pittsburg, Pa., Supply Main	42 and 51	26,000
1902	Jersey City, N. J.	72	93,000
1902	Boston, Mass.	......	....
1903	Newark, N. J.	60	39,300
1903	Troy, N. Y.	33	35,300
1903	Schenectady, N. Y.	36	23,000
1905	Lynchburg, Va.	30	12,000
1905	Wilmington, Del.	43	8,000
1905	Wilmington, Del.	48	12,000
1905	Passaic Water Co.	42	8,000
1905	Passaic Water Co.	48	2,000
1905–6	Pittsburg, Pa.	50	26,500
1905–6	Pittsburg, Pa.	36	4,100
1905–6	Pittsburg, Pa.	24 and 96	11,800
1905	Pittsburg, Pa.	30	2,600

SAFE PRESSURES AND EQUIVALENT HEADS OF WATER FOR CAST-IRON PIPE OF DIFFERENT SIZES AND THICKNESSES.

(Calculated by F. H. Lewis from Fanning's Formula.)

Thickness.	Size of Pipe. 4 Inches.		6 Inches.		8 Inches.		10 Inches.		12 Inches.		14 Inches.		16 Inches.		18 Inches.		20 Inches.	
	Pressure in Pounds.	Head in Feet.	Pressure in Pounds.	Head in Feet.	Pressure in Pounds.	Head in Feet.	Pressure in Pounds.	Head in Feet.	Pressure in Pounds.	Head in Feet.	Pressure in Pounds.	Head in Feet.	Pressure in Pounds.	Head in Feet.	Pressure in Pounds.	Head in Feet.	Pressure in Pounds.	Head in Feet.
7/16	112	258	49	112	18	42	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1/2	224	516	124	280	74	171	44	101	24	55	.....	.....	.....	.....	.....	.....	.....	.....
9/16	336	774	199	458	130	300	89	205	62	143	42	97	.....	.....	.....	.....	.....	.....
5/8	.....	.....	274	631	186	429	132	304	99	228	74	170	56	129	41	95	.....	.....
11/16	.....	.....	.....	.....	.....	.....	177	408	137	316	106	244	84	194	66	152	51	118
3/4	.....	.....	.....	.....	.....	.....	224	516	174	401	138	316	112	258	91	210	74	170
13/16	.....	.....	.....	.....	.....	.....	.....	.....	212	488	170	392	140	323	116	267	96	221
7/8	.....	.....	.....	.....	.....	.....	.....	.....	249	574	202	465	168	387	141	325	119	274
15/16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	234	538	196	452	166	382	141	325
1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	266	612	224	516	191	440	164	378
1 1/8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	216	497	209	481
1 1/4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	256	589

SAFE PRESSURES AND EQUIVALENT HEADS OF WATER FOR CAST-IRON PIPE OF DIFFERENT SIZES AND THICKNESSES—(*Continued*).

Thickness.	Size of Pipe.																	
	22 Inches.		24 Inches.		27 Inches.		30 Inches.		33 Inches.		36 Inches.		42 Inches.		48 Inches.		60 Inches.	
	Pressure in Pounds.	Head in Feet.	Pressure in Pounds.	Head in Feet.	Pressure in Pounds.	Head in Feet.	Pressure in Pounds.	Head in Feet.	Pressure in Pounds.	Head in Feet.	Pressure in Pounds.	Head in Feet.	Pressure in Pounds.	Head in Feet.	Pressure in Pounds.	Head in Feet.	Pressure in Pounds.	Head in Feet
$\frac{11}{16}$	40	92	30	69	19	64	....	....	....	....	....	....	....	....	....	....	....	....
$\frac{3}{4}$	60	138	49	113	36	83	24	55	....	....	....	....	....	....	....	....	....	....
$\frac{13}{16}$	80	184	68	157	52	120	39	90	....	....	....	....	....	....	....	....	....	....
$\frac{7}{8}$	101	233	86	198	69	159	54	124	42	97	32	74	....	....	....	....	....	....
$\frac{15}{16}$	121	279	105	242	85	196	69	159	55	127	44	101	....	....	....	....	....	....
1	142	327	124	286	102	235	84	194	69	159	57	131	38	88	24	55	....	....
$1\frac{1}{8}$	182	419	161	371	135	311	114	263	96	221	82	189	59	136	43	99	....	....
$1\frac{1}{4}$	224	516	199	458	169	389	144	332	124	286	107	247	81	187	62	143	34	78
$1\frac{3}{8}$	....	....	237	546	202	465	174	401	151	348	132	304	103	237	81	187	49	113
$1\frac{1}{2}$	....	....	....	....	236	544	204	470	178	410	157	362	124	286	99	228	64	147
$1\frac{5}{8}$	....	....	....	....	....	....	234	538	205	472	182	419	145	334	118	272	79	182
$1\frac{3}{4}$	....	....	....	....	....	....	....	....	233	537	207	477	167	385	136	313	94	217
$1\frac{7}{8}$	....	....	....	....	....	....	....	....	....	....	....	....	188	433	155	357	109	251
2	....	....	....	....	....	....	....	....	....	....	....	....	210	484	174	401	124	286
$2\frac{1}{8}$	....	....	....	....	....	....	....	....	....	....	....	....	....	....	193	445	139	320
$2\frac{1}{4}$	....	....	....	....	....	....	....	....	....	....	....	....	....	....	212	488	154	355
$2\frac{1}{2}$	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	184	424
$2\frac{3}{4}$	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	214	482

Formula for Thickness of Cast-Iron Water-Pipe.

$t = .00008hd + 0.1d + .36$ .... Shedd;
$t = .00006hd + .0133d + .296$ .... Warren Foundry;
$t = .000058hd + .0152 + .312$ .... Francis;
$t = .000048hd + .013d + .32$ .... Dupuit;
$t = .00004hd + .1\sqrt{d} + .15$ .... Box;
$t = .000135hd + .4 - .0011d$ .... Whitman;
$t = .00006(h + 230d) + .333 - .0033d$ ...... Fanning;
$t = .00015hd + .25 - .0052d$ .... Meggs;
in which t = thickness in inches, h = head in feet, d = diameter.

SIZE AND WEIGHT OF LEAD PIPE.

Calibre.	Ultimate Strength.	Working Strength.	Weight per Foot. Lbs.	Oz.
1/8 inch tubing	....	....		3½
1/4 " extra-light tubing	....	....		4
1/4 " light tubing	....	....		6
1/4 " medium tubing	....	....		8
1/4 " strong tubing	....	....		10
1/4 " extra strong	....	....	1	2
3/8 " aqueduct	1187	296	0	8
3/8 " light	1342	335	0	12
3/8 " medium	1381	347	1	0
3/8 " strong	1627	406	1	8
3/8 " extra strong	1968	492	2	0
1/2 " aqueduct	782	195	0	10
1/2 " extra light	980	245	0	12
1/2 " light	1285	321	1	0
1/2 " medium	1393	343	1	4
1/2 " strong	1655	413	1	12
1/2 " extra strong	1787	446	2	8
5/8 " aqueduct	708	177	0	12
5/8 " extra light	795	198	1	4
5/8 " light	987	246	1	12
5/8 " medium	1152	288	2	0
5/8 " strong	1380	345	2	8
5/8 " extra strong	1548	387	3	0
3/4 " aqueduct	505	126	1	0
3/4 " extra light	782	195	1	8
3/4 " light	865	216	2	0
3/4 " medium	1072	268	2	4
3/4 " strong	1225	306	3	0
3/4 " extra strong	1462	365	3	8
1 " aqueduct	518	129	1	8
1 " extra light	562	140	2	0
1 " light	745	186	2	8
1 " medium	857	214	3	4
1 " strong	910	227	4	0
1 " extra strong	1230	307	4	12
1¼ " aqueduct	350	87	2	0
1¼ " extra light	420	105	2	8
1¼ " light	546	136	3	0
1¼ " medium	685	171	3	12
1¼ " strong	823	205	4	12
1¼ " extra strong	962	240	6	0
1½ " aqueduct	315	78	3	0

SIZE AND WEIGHT OF LEAD PIPE—(*Continued*).

Calibre.	Ultimate Strength.	Working Strength.	Weight per Foot. Lbs.	Oz.
1½ inch extra light	430	107	3	8
1½ " light	506	126	4	0
1½ " medium	628	157	5	0
1½ " strong	700	175	6	0
1½ " extra strong	742	185	7	8
1¾ " extra light	....	....	3	12
1¾ " light	....	....	4	8
1¾ " medium	318	79	5	8
1¾ " strong	....	93	6	8
1¾ " extra strong	....	116	8	0
2 " waste	200	50	3	0
2 " extra light	260	65	4	0
2 " light	360	90	5	0
2 " medium	405	101	7	0
2 " strong	511	127	8	0
2 " extra strong	611	152	9	0
2½ " $\frac{3}{16}$ thick	....	....	8	0
2½ " ¼ "	....	....	11	0
2½ " $\frac{5}{16}$ thick	....	....	14	0
2½ " ⅜ "	....	....	17	0
3 " waste	....	....	5	0
3 " $\frac{3}{16}$ thick	....	....	9	0
3 " ¼ "	....	....	12	0
3 " $\frac{5}{16}$ "	....	....	16	0
3 " ⅜ "	....	....	20	0
3½ " ¼ "	....	....	15	0
3½ " $\frac{5}{16}$ "	....	....	18	0
3½ " ⅜ "	....	....	21	0
4 " waste	....	....	5	0
4 " ⅛ thick	....	....	7	0
4 " ¼ "	....	....	16	0
4 " $\frac{5}{16}$ "	....	....	21	0
4 " ⅜ "	....	....	25	0
4 " $\frac{7}{16}$ "	....	....	30	0
4½ " waste	....	....	6	0
5 " "	....	....	8	0

PURE BLOCK-TIN PIPE.

Calibre.	Wei'ht per Foot. Oz.	Calibre.	Weight per Foot. Lbs.	Oz.
⅛ inch strong	2½	½ inch double extra strong		15
¼ " extra strong	5	⅝ " extra strong		9
¼ " double extra strong	6	⅝ " double extra strong		14
$\frac{5}{16}$ " double extra strong	6½	¾ " extra strong		11
⅜ " extra strong	6	¾ " double extra strong	1	0
⅜ " double extra strong	8	1 " extra strong		14
½ " strong	6½	1 " double extra strong	1	4
½ " extra strong	10			

Relative Weights of Metals.

Cubic inches multiplied by:		Cylindrical inches multiplied by:	
.263 =	pounds of cast iron	.2065 =	pounds of cast iron
.281 =	" " wrought iron	.2168 =	" " wrought iron
.283 =	" " steel	.2223 =	" " steel
.3225 =	" " copper	.2533 =	" " copper
.3037 =	" " brass	.2385 =	" " brass
.26 =	" " zinc	.2042 =	" " zinc
.4103 =	" " lead	.3223 =	" " lead
.2636 =	" " tin	.207 =	" " tin
.4908 =	" " mercury	.3854 =	" " mercury

Space Occupied by Fuel.

Coals of the same size coming from different mines vary in density, but the space given below is an average for best fuels:

Stove Anthracite	33	cubic feet per 2,000 lbs.
Egg "	32.5	" " " 2,000 lbs.
Soft Coal	40	" " " 2,000 lbs.
Coke	68	" " " 2,000 lbs.

Weight of Liquids per Gallon.

1 Gallon.	Pounds.
Ale	8.33
Acid, Nitric	10.58
Acid, Sulphuric	15.42
Acid, Muriatic	10.
Alcohol, Commerce	6.74
Alcohol, Proof Spirit	7.94
Naphtha	7.08
Oil, Linseed	7.75
Oil of Turpentine	7.25
Oil, Whale	7.25
Petroleum	7.35
Vinegar	8.43
Salt Water	8.59
Tar	8.43
Distilled Water	8.34

Weight of Round Zinc Rods.

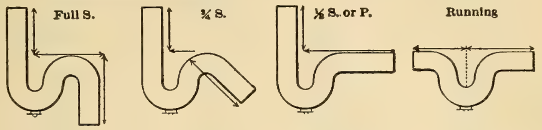
Per Lineal Foot.

$\frac{3}{8}$ inch diameter	.33 pounds.
$\frac{1}{2}$ " "	.58 "
$\frac{5}{8}$ " "	.90 "
$\frac{3}{4}$ " "	1.30 "
$\frac{7}{8}$ " "	1.78 "
1 " "	2.32 "

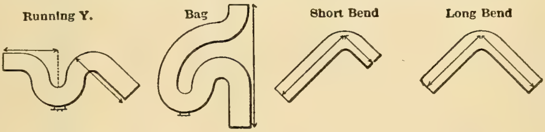
DRAWN LEAD TRAPS AND BENDS.

Dimension Scale for Regular Traps and Bends.

Showing length of Inlet and Outlet up to Running Y, length over all of Bag Trap and from center to ends of Long and Short Bends.



Size, Inter. Diam.	Full S. Inlet.	Outlet.	¾ S. Inlet.	Outlet.	½ S. or P. Inlet.	Outlet.	Running Inlet.	Outlet.
1¼ inch...	4¼ inches	6¼	4¼ inches	5¼	4½ inches	6	4½ inches	5½
1½ inch...	4½ inches	7	4½ inches	6	4½ inches	7	5¼ inches	6¼
2 inch...	4½ inches	8	4½ inches	7½	4½ inches	8	5¼ inches	7½
3 inch...	4 inches	10½	4 inches	10	4 inches	9½	7½ inches	7½
4 inch...	3¼ inches	11½	3¼ inches	11	3¼ inches	10	8 inches	8
4½ inch...	3½ inches	12½	3½ inches	13½	3½ inches	10¼	9½ inches	6½



Size, Inter. Diam.	Running Y. Inlet.	Outlet.	Bag Length Over All.	Short Bend Center to Ends.		Long Bend Center to Ends.
1¼ inch...	4½ inches	5¼	11½ inches	6 inches	3½	6 inches
1½ inch...	5¼ inches	6	13 inches	7 inches	4	7 inches
2 inch...	5¼ inches	7½	15 inches	7¾ inches	3¾	7¾ inches
3 inch...	7½ inches	10	18½ inches	8¼ inches	4¼	8¼ inches
4 inch...	8 inches	11	22½ inches	10 inches	5½	10 inches
4½ inch...	9½ inches	13½	23½ inches	11 inches	6¼	11 inches

Dimension Scale for Extra Long Traps.

Showing length over all of S and Bag Traps and Inlet and Outlet of ¾ S, ½ S, Running and Running Y.

Size, Internal Diam. Measurements taken as shown by Arrows on Cuts of Regular Traps.	Full S. Length Over All.	¾ S. Inlet.	Outlet.	½ S or P. Inlet.	Outlet.
1¼ inch................	24 inches	4¼ inches	16¼	4¼ inches	14¼
1½ inch................	24 inches	4½ inches	15¾	4½ inches	14
2 inch................	24 inches	4¼ inches	15½	4½ inches	14

Size, Internal Diam. Measurements taken as shown by Arrows on Cuts of Regular Traps.	Running. Inlet.	Outlet.	Running Y. Inlet.	Outlet.	Bag. Length Over All.
1¼ inch...............	4½ inches	17½	4½ inches	16¼	24 inches
1½ inch...............	5¼ inches	16¾	5¼ inches	15¾	24 inches
2 inch...............	5¼ inches	16¾	5¼ inches	15½	24 inches

CAPACITY AND SIZE OF GALVANIZED BOILERS.

Capacity.	Size.	Weight of Boiler.	Total Weight Filled with Water.
18 gallons........	3 feet by 12 inches	47	196
21 "	3½ " " 12 "	49	224
24 "	4 " " 12 "	57	257
24 "	3 " " 14 "	52	255
27 "	4½ " " 12 "	66	291
28 "	3½ " " 14 "	66	299
30 "	5 " " 12 "	72	322
32 "	4 " " 14 "	72	339
35 "	5 " " 13 "	76	367
36 "	6 " " 12 "	85	384
36 "	4½ " " 14 "	78	377
40 "	5 " " 14 "	85	418
42 "	4 " " 16 "	95	444
47 "	4½ " " 16 "	102	493
48 "	6 " " 14 "	102	503
52 "	5 " " 16 "	119	551
53 "	4 " " 18 "	119	562
63 "	6 " " 16 "	146	670
66 "	5 " " 18 "	150	699
79 "	6 " " 18 "	171	829
82 "	5 " " 20 "	192	875
98 "	6 " " 20 "	210	1026
100 "	5 " " 22 "	220	1053
120 "	6 " " 22 "	265	1264
120 "	5 " " 24 "	260	1259
144 "	6 " " 24 "	332	1531
168 "	7 " " 24 "	348	1747
192 "	8 " " 24 "	391	1990

TABLE OF WEIGHTS PER LINEAL FOOT OF SEAMLESS BRASS AND COPPER TUBING.

Iron Pipe Sizes.

Made to correspond with iron tubes and to fit iron tube fittings.

Same as Iron Size.	Exact Outside Diameter. Decimals.	Exact Inside Diameter. Decimals.	About Inside Diameter. Fractions.	Weight per Foot. Brass.	Weight per Foot. Copper.
Inches.	Inches.	Inches.	Inches.	Lbs.	Lbs.
⅛	.405	.281	¼	.25	.26
¼	.540	.375	$\frac{11}{32}$	.43	.45
⅜	.675	.484	$\frac{15}{32}$	.62	.65
½	.840	.625	⅝	.90	.95
¾	1.04	.822	$\frac{27}{32}$	1.25	1.31
1	1.315	1.062	$1\frac{3}{32}$	1.70	1.79
1¼	1.66	1.368	$1\frac{11}{32}$	2.50	2.63
1½	1.90	1.600	$1\frac{19}{32}$	3.00	3.15
2	2.375	2.062	$2\frac{1}{16}$	4.00	4.20
2½	2.875	2.500	$2\frac{7}{16}$	5.75	6.04
3	3.50	3.062	$3\frac{1}{16}$	8.30	8.72
3½	4.00	3.5000	3½	10.90	11.45
4	4.50	4.000	$4\frac{1}{32}$	12.70	13.33
4½	5.00	4.5000	$4\frac{17}{32}$	13.90	14.60
5	5.563	5.062	$5\frac{1}{32}$	15.75	16.54
6	6.625	6.125	$6\frac{1}{16}$	18.31	19.23

SEAMLESS BRASS AND COPPER TUBING—(*Continued*).

Extra-heavy Iron Pipe Sizes.

Same as Extra-heavy Iron Pipe.	Exact Outside Diameter.	Exact Inside Diameter.	Approximate Weight in Pounds per Foot.	
			Brass.	Copper.
Inches.	Inches.	Inches.	Lbs.	Lbs.
1/8	.405	.205	.370	.389
1/4	.504	.294	.625	.651
3/8	.675	.421	.830	.872
1/2	.840	.542	1.200	1.260
3/4	1.050	.736	1.660	1.743
1	1.315	.951	2.360	2.478
1 1/4	1.660	1.272	3.300	3.465
1 1/2	1.900	1.494	4.250	4.462
2	2.375	1.933	5.460	5.733
2 1/2	2.875	2.315	8.300	8.715
3	3.500	2.892	11.200	11.760
3 1/2	4.00	3.358	13.700	14.385
4	4.50	3.818	16.500	17.325
5	5.563	4.813	22.800	23.940
6	6.625	5.750	32.000	33.600

SIZE, WEIGHTS, ETC., OF VITRIFIED SALT-GLAZED SEWER-PIPE.

Calibre of Pipe.	Thickness of Pipe.	Weight per Foot.	Feet to 15-ton Car Load.
3 inches	1/2 inch	6 pounds	5000
4 "	1/2 "	7 1/2 "	4000
5 "	5/8 "	11 1/2 "	2610
6 "	3/4 "	16 "	1880
8 "	3/4 "	22 "	1366
10 "	7/8 "	31 "	970
12 "	7/8 "	41 "	734
14 "	1 "	50 "	600
16 "	1 1/8 inches	66 "	456
18 "	1 1/4 "	80 "	376
20 "	1 1/4 "	90 "	334
22 "	1 3/8 "	100 "	300
24 "	1 1/2 "	120 "	250
30 "	1 3/4 "	190 "	158

DOUBLE-STRENGTH PIPE.

Calibre of Pipe.	Thickness of Pipe.	Weight per Foot.	Feet to 15-ton Car Load.
15 inches	1 1/4 inches	65 pounds	462
18 "	1 1/2 "	100 "	300
21 "	1 3/4 "	132 "	228
24 "	2 "	175 "	172
30 "	2 1/2 "	260 "	116

TABLE OF WEIGHTS PER LINEAL FOOT OF BRASS AND COPPER RODS.

Inches.	Brass.		Copper.	
	Round.	Square.	Round.	Square.
	Pounds.	Pounds.	Pounds.	Pounds.
1/16	.011	.014	.01155	.0147
1/8	.045	.055	.047	.060
3/16	.100	.125	.106	.13497
1/4	.175	.225	.189	.241
5/16	.275	.350	.296	.377
3/8	.395	.510	.426	.542
7/16	.540	.690	.579	.737
1/2	.710	.905	.757	.964
9/16	.90	1.15	.958	1.22
5/8	1.10	1.40	1.182	1.51
11/16	1.35	1.72	1.431	1.82
3/4	1.66	2.05	1.703	2.17
13/16	1.85	2.40	1.998	2.54
7/8	2.15	2.75	2.318	2.95
15/16	2.48	3.15	2.660	3.39
1	2.85	3.65	3.03	3.86
1 1/16	3.20	4.08	3.42	4.35
1 1/8	3.57	4.55	3.831	4.88
1 3/16	3.97	5.08	4.269	5.44
1 1/4	4.41	5.65	4.723	6.01
1 5/16	4.86	6.22	5.21	6.63
1 3/8	5.35	6.81	5.723	7.24
1 7/16	5.85	7.45	6.255	7.97
1 1/2	6.37	8.13	6.811	8.67
1 9/16	6.92	8.83	7.39	9.41
1 5/8	7.48	9.55	7.993	10.18
1 11/16	8.05	10.27	8.45	10.73
1 3/4	8.65	11.00	9.27	11.80
1 13/16	9.29	11.82	9.76	12.43
1 7/8	9.95	12.68	10.642	13.55
1 15/16	10.58	13.50	11.11	14.15
2	11.25	14.35	12.108	15.42
2 1/8	12.78	16.27	13.668	17.42
2 1/4	14.32	18.24	15.325	19.51
2 3/8	15.96	20.32	17.075	21.74
2 1/2	17.68	22.53	18.916	24.09
2 5/8	19.50	24.83	20.856	26.56
2 3/4	21.40	27.25	22.891	29.05
2 7/8	23.39	29.78	25.019	31.86
3	25.47	32.43	27.243	34.69
3 1/4	30.45	38.77	31.972	40.71
3 1/2	35.31	44.96	37.081	47.22
4	46.124	58.73	48.433	61.67

To find the weight of octagon rod, take the weight of round rod of a given size and multiply by 1.084.

To find the weight of hexagon rod, take the weight of round rod of a given size and multiply by 1.12.

These tables are theoretically correct, but variations must be expected in practice.

APPROXIMATE WEIGHT PER LINEAL FOOT OF STANDARD SIZES. RECTANGULAR OR FLAT COPPER BARS.

Size, Inch.	Lbs.	Size, Inch.	Lbs.	Size, Inch.	Lbs.
$\frac{1}{16} \times \frac{1}{2}$	.12	$\frac{3}{16} \times \frac{1}{2}$	.36	$\frac{1}{4} \times 1\frac{3}{4}$	1.68
$\frac{1}{16} \times \frac{5}{8}$	.15	$\frac{3}{16} \times \frac{5}{8}$	.45	$\frac{1}{4} \times 2$	1.93
$\frac{1}{16} \times \frac{3}{4}$	.18	$\frac{3}{16} \times \frac{3}{4}$	.54	$\frac{3}{8} \times 1$	1.44
$\frac{1}{16} \times \frac{7}{8}$	.21	$\frac{3}{16} \times \frac{7}{8}$	.63	$\frac{3}{8} \times 1\frac{1}{4}$	1.80
$\frac{1}{16} \times 1$	.24	$\frac{3}{16} \times 1$	.72	$\frac{3}{8} \times 1\frac{1}{2}$	2.16
$\frac{1}{16} \times 1\frac{1}{4}$	.30	$\frac{3}{16} \times 1\frac{1}{4}$	.90	$\frac{3}{8} \times 1\frac{3}{4}$	2.52
$\frac{1}{16} \times 1\frac{1}{2}$	.36	$\frac{3}{16} \times 1\frac{1}{2}$	1.08	$\frac{3}{8} \times 2$	2.88
$\frac{1}{8} \times \frac{1}{2}$	.24	$\frac{3}{16} \times 1\frac{3}{4}$	1.26	$\frac{3}{8} \times 2\frac{1}{4}$	3.24
$\frac{1}{8} \times \frac{5}{8}$	.30	$\frac{3}{16} \times 2$	1.44	$\frac{3}{8} \times 2\frac{1}{2}$	3.60
$\frac{1}{8} \times \frac{3}{4}$	.36	$\frac{1}{4} \times \frac{1}{2}$	.48	$\frac{1}{2} \times 1$	1.93
$\frac{1}{8} \times \frac{7}{8}$	.42	$\frac{1}{4} \times \frac{5}{8}$	.60	$\frac{1}{2} \times 1\frac{1}{4}$	2.41
$\frac{1}{8} \times 1$	.48	$\frac{1}{4} \times \frac{3}{4}$	.72	$\frac{1}{2} \times 1\frac{1}{2}$	2.89
$\frac{1}{8} \times 1\frac{1}{4}$	.60	$\frac{1}{4} \times \frac{7}{8}$	.84	$\frac{1}{2} \times 1\frac{3}{4}$	3.37
$\frac{1}{8} \times 1\frac{1}{2}$	.72	$\frac{1}{4} \times 1$	.97	$\frac{1}{2} \times 2$	3.86
$\frac{1}{8} \times 1\frac{3}{4}$	.84	$\frac{1}{4} \times 1\frac{1}{4}$	1.20	$\frac{1}{2} \times 2\frac{1}{4}$	4.34
$\frac{1}{8} \times 2$	.96	$\frac{1}{4} \times 1\frac{1}{2}$	1.44	$\frac{1}{2} \times 2\frac{1}{2}$	4.82

APPROXIMATE WEIGHT PER LINEAL FOOT OF STANDARD SIZES. RECTANGULAR OR FLAT BRASS BARS.

Size, Inch.	Lbs.	Size, Inch.	Lbs.	Size, Inch.	Lbs.
$\frac{1}{16} \times \frac{1}{2}$	.114	$\frac{3}{16} \times \frac{1}{2}$	.342	$\frac{1}{4} \times 1\frac{3}{4}$	1.596
$\frac{1}{16} \times \frac{5}{8}$	.142	$\frac{3}{16} \times \frac{5}{8}$	.427	$\frac{1}{4} \times 2$	1.833
$\frac{1}{16} \times \frac{3}{4}$	.171	$\frac{3}{16} \times \frac{3}{4}$	.513	$\frac{3}{8} \times 1$	1.368
$\frac{1}{16} \times \frac{7}{8}$	.199	$\frac{3}{16} \times \frac{7}{8}$	.598	$\frac{3}{8} \times 1\frac{1}{4}$	1.710
$\frac{1}{16} \times 1$	.228	$\frac{3}{16} \times 1$	.684	$\frac{3}{8} \times 1\frac{1}{2}$	2.052
$\frac{1}{16} \times 1\frac{1}{4}$	.285	$\frac{3}{16} \times 1\frac{1}{4}$	.855	$\frac{3}{8} \times 1\frac{3}{4}$	2.394
$\frac{1}{16} \times 1\frac{1}{2}$	.342	$\frac{3}{16} \times 1\frac{1}{2}$	1.026	$\frac{3}{8} \times 2$	2.736
$\frac{1}{8} \times \frac{1}{2}$	.228	$\frac{3}{16} \times 1\frac{3}{4}$	1.197	$\frac{3}{8} \times 2\frac{1}{4}$	3.078
$\frac{1}{8} \times \frac{5}{8}$	.285	$\frac{3}{16} \times 2$	1.368	$\frac{3}{8} \times 2\frac{1}{2}$	3.420
$\frac{1}{8} \times \frac{3}{4}$	.342	$\frac{1}{4} \times \frac{1}{2}$	.450	$\frac{1}{2} \times 1$	1.833
$\frac{1}{8} \times \frac{7}{8}$	.399	$\frac{1}{4} \times \frac{5}{8}$	.570	$\frac{1}{2} \times 1\frac{1}{4}$	2.289
$\frac{1}{8} \times 1$	.456	$\frac{1}{4} \times \frac{3}{4}$	.684	$\frac{1}{2} \times 1\frac{1}{2}$	2.745
$\frac{1}{8} \times 1\frac{1}{4}$	.570	$\frac{1}{4} \times \frac{7}{8}$	.798	$\frac{1}{2} \times 1\frac{3}{4}$	3.201
$\frac{1}{8} \times 1\frac{1}{2}$	.684	$\frac{1}{4} \times 1$	.921	$\frac{1}{2} \times 2$	3.667
$\frac{1}{8} \times 1\frac{3}{4}$	.798	$\frac{1}{4} \times 1\frac{1}{4}$	1.140	$\frac{1}{2} \times 2\frac{1}{4}$	4.123
$\frac{1}{8} \times 2$	.912	$\frac{1}{4} \times 1\frac{1}{2}$	1.368	$\frac{1}{2} \times 2\frac{1}{2}$	4.579

LEAD WIRE.

Table Showing Diameter and Corresponding B. & S. Gauge Numbers.

Diameter in Brown & Sharp Gauge.	Corresponding Decimal Equivalent.	Corresponding Fractional Equivalent.	Approximate Number of Feet to Pound.
No. 6	.16202	$\frac{5}{32}$ (F)	10
No. 8	.12849	$\frac{1}{8}$ (F)	$15\frac{1}{2}$
No. 10	.10189	$\frac{7}{64}$ (S)	25
No. 11	.09074	$\frac{3}{32}$ (S)	31
No. 12	.08081	$\frac{5}{64}$ (F)	40
No. 13	.07196	$\frac{5}{64}$ (S)	50
No. 14	.06408	$\frac{1}{16}$ (F)	$62\frac{1}{2}$
No. 15	.05706	$\frac{1}{16}$ (S)	77
No. 16	.05082	$\frac{3}{64}$ (F)	100
No. 17	.04525	$\frac{3}{64}$ (S)	125
No. 18	.0403	$\frac{3}{64}$ (S)	166
No. 19	.03589	$\frac{1}{32}$ (F)	200
No. 20	.03196	$\frac{1}{32}$	250
No. 21	.02846	$\frac{1}{36}$	332
No. 22	.02535	$\frac{1}{40}$	400
No. 23	.02257	$\frac{1}{44}$	510

NOTE. — Sizes above No. 6 B. & S. gauge increase by $\frac{1}{32}$ of an inch. (F) = Full. (S) = Scant.

WEIGHT, ETC., OF TERRA COTTA FLUE-LININGS.

Inside Measure.	Outside Measure.	Form.	Weight per Foot.	Feet to Car Load of 15 Tons.
Inches.	Inches.		Pounds.	
5	7	Round	14	2144
6	8	"	19	1580
8	10	"	22	1364
10	$12\frac{1}{2}$	"	30	1000
$3\frac{1}{2}\times 7\frac{1}{2}$	$4\frac{1}{2}\times 8\frac{1}{2}$	Square	10	3000
7×7	$8\frac{1}{2}\times 8\frac{1}{2}$	"	20	1500
$7\times 11\frac{1}{2}$	$8\frac{1}{2}\times 13$	"	30	1000
$7\times 15\frac{1}{2}$	$8\frac{1}{2}\times 17$	"	33	910
$11\frac{1}{2}\times 11\frac{1}{2}$	13×13	"	37	810
$11\frac{1}{2}\times 15\frac{1}{2}$	13×17	"	40	750
$15\frac{1}{2}\times 15\frac{1}{2}$	17×17	"	50	600

WEIGHTS OF HOT AIR PIPE, ETC.

Expressed in Pounds and Fractions of Pounds.

Sizes in Inches.	7 In.	8 In.	9 In.	10 In.	12 In.	14 In.	16 In.	18 In.	20 In.
Hot air pipe per foot, —									
IC	$\frac{31}{34}$	$\frac{33}{34}$	$1\frac{3}{19}$	$1\frac{5}{17}$	$1\frac{9}{17}$	......	......	......	......
IX	$1\frac{3}{34}$	$1\frac{4}{17}$	$1\frac{7}{17}$	$1\frac{10}{17}$	$1\frac{16}{17}$	$2\frac{5}{14}$	$2\frac{4}{7}$	$2\frac{29}{34}$	3
Hot air elbows, —									
3 piece, IC	$\frac{3}{4}$	$\frac{7}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$2\frac{1}{8}$	......	......	......	......
4 piece, IC	$\frac{7}{8}$	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{1}{2}$	2	......	......	......	......
4 piece, IX	1	$1\frac{1}{4}$	$1\frac{5}{8}$	$1\frac{7}{8}$	$2\frac{1}{2}$	$3\frac{1}{4}$	$3\frac{7}{8}$	$5\frac{1}{2}$	$6\frac{1}{2}$
Hot air angles, —									
45° IC	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	......	......	......	......	......
45° IX	......	$\frac{3}{4}$	$1\frac{3}{16}$	1	$1\frac{1}{2}$	$1\frac{7}{8}$	$2\frac{3}{4}$	3	$3\frac{5}{8}$
$22\frac{1}{2}$° IC	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{5}{8}$	1	......	......	......	......
$22\frac{1}{2}$° IX	......	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$
Hot air dampers, style "A"	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{7}{8}$	$1\frac{1}{8}$	$1\frac{3}{8}$	2	$2\frac{1}{2}$
Galvanized iron pipe, —									
Per foot	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{4}$	$2\frac{5}{8}$	$3\frac{1}{4}$	$3\frac{5}{8}$	$4\frac{5}{16}$	$4\frac{13}{16}$
Elbows	$1\frac{1}{2}$	$1\frac{7}{8}$	$2\frac{3}{8}$	$2\frac{3}{4}$	$3\frac{5}{8}$	$4\frac{1}{2}$	$5\frac{7}{8}$	$7\frac{1}{2}$	9
Angles, 45°	1	$1\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$2\frac{1}{2}$	3	$3\frac{3}{4}$	$4\frac{1}{2}$	$5\frac{1}{2}$
Angles, $22\frac{1}{2}$°	$\frac{13}{16}$	$\frac{15}{16}$	$1\frac{1}{16}$	1	$1\frac{3}{4}$	2	$2\frac{5}{8}$	$3\frac{1}{4}$	$3\frac{1}{2}$
Smoke pipe dampers	$2\frac{1}{2}$	$3\frac{1}{8}$	4	5	6	......	......	......	......
Safety thimbles	$1\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{7}{16}$	$1\frac{1}{2}$	$1\frac{3}{4}$	......	......	......	......
Top bonnet collars	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{9}{16}$	......	......	......	......
Side bonnet collars	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{3}{4}$	2	$2\frac{3}{4}$	$3\frac{1}{8}$
Pitch bonnet collars	$\frac{5}{8}$	$\frac{5}{8}$	$1\frac{11}{16}$	$\frac{3}{4}$	1	......	......	......	......
Cold air collars	......	......	......	......	......	$1\frac{1}{2}$	2	$2\frac{1}{4}$	$2\frac{5}{8}$

WEIGHT OF MINERAL WOOL.

Average Weight.	Pounds per Cubic Foot.	Square Foot One Inch Thick.	Cubic Feet to Ton.
		Pound.	
Ordinary slag wool	12	1	166
Selected slag wool	9	$\frac{3}{4}$	223
Extra slag wool	6	$\frac{1}{2}$	333
Ordinary rock wool	12	1	166
Selected rock wool	8	$\frac{2}{3}$	250
Extra rock wool	6	$\frac{1}{2}$	333

Mineral wool is put up in bags containing from 40 to 60 pounds.

THICKNESS AND WEIGHT PER SQUARE FOOT OF SHEET LEAD.

12 ounce lead is .013 inch thick.
1 pound lead is $\frac{1}{64}$ inch thick.
$1\frac{1}{2}$ " " " $\frac{1}{43}$ " "
2 " " " $\frac{1}{32}$ " "
$2\frac{1}{2}$ " " " $\frac{1}{24}$ " "
3 " " " $\frac{3}{64}$ " "
4 " " " $\frac{1}{16}$ " "
5 " " " $\frac{5}{64}$ " "
6 " " " $\frac{3}{32}$ " "
7 " " " $\frac{7}{64}$ " "

8 pound lead is $\frac{1}{8}$ inch thick.
10 " " " $\frac{5}{32}$ " "
12 " " " $\frac{3}{16}$ " "
14 " " " $\frac{7}{32}$ " "
16 " " " $\frac{1}{4}$ " "
20 " " " $\frac{5}{16}$ " "
24 " " " $\frac{3}{8}$ " "
32 " " " $\frac{1}{2}$ " "
60 " " " 1 " "

WEIGHT PER 12-FOOT LENGTHS OF STANDARD CAST IRON PIPE AND TO REDUCE ANY LENGTH TO TONS.

Diameter Pipe. Ins.	Weight per 12-Ft. Length.	Multiply Total Length of Pipe by
4	264	.011
6	396	.0165
8	504	.021
10	720	.03
12	900	.0375
14	1,200	.05
16	1,500	.0625
18	2,004	.0835
20	2,400	.1
24	3,000	.125
30	4,008	.167
36	5,400	.225
42	7,200	.3
48	8,700	.3625
60	12,900	.5375
72	18,720	.78

APPROXIMATE NUMBER OF ROUND HEAD RIVETS IN ONE POUND.

Size.	$\frac{3}{8}$	0	$\frac{5}{16}$	1	2	3	$\frac{1}{4}$
$\frac{3}{8}$	......	......	......	......	......	......	......
$\frac{1}{2}$	32	42	51	57	65	75	80
$\frac{5}{8}$	29	37	45	50	57	67	70
$\frac{3}{4}$	26	33	41	45	51	59	63
$\frac{7}{8}$	24	30	37	41	46	54	57
1	22	28	34	37	42	49	52
$1\frac{1}{8}$	20	26	31	34	39	45	47
$1\frac{1}{4}$	19	24	29	32	36	42	44
$1\frac{3}{8}$	18	22	27	29	33	39	41
$1\frac{1}{2}$	17	21	25	28	31	37	38
$1\frac{3}{4}$	15	18	22	24	27	33	34
2	13	17	20	22	25	29	30
$2\frac{1}{4}$	12	15	18	19	22	27	28
$2\frac{1}{2}$	11	14	17	18	20	24	25
$2\frac{3}{4}$	10	13	15	17	19	22	23
3	9	12	14	15	17	21	22
$3\frac{1}{4}$	$8\frac{1}{2}$	11	13	14	16	19	20
$3\frac{1}{2}$	8	$10\frac{1}{2}$	12	$13\frac{1}{2}$	15	18	19
$3\frac{3}{4}$	$7\frac{1}{2}$	$9\frac{3}{4}$	$11\frac{3}{4}$	$12\frac{3}{4}$	14	17	18
4	$7\frac{1}{4}$	$9\frac{1}{4}$	11	12	13	16	17
$4\frac{1}{4}$	7	$8\frac{3}{4}$	$10\frac{1}{2}$	$11\frac{1}{4}$	$12\frac{3}{4}$	15	16
$4\frac{1}{2}$	$6\frac{1}{2}$	$8\frac{1}{4}$	10	$10\frac{3}{4}$	12	14	15

Size.	4	5	6	$\frac{3}{16}$	7	8	9
$\frac{3}{8}$	......	......	154	188	221	256	334
$\frac{1}{2}$	89	108	131	159	185	215	278
$\frac{5}{8}$	78	94	114	138	158	185	238
$\frac{3}{4}$	70	84	101	122	139	163	208
$\frac{7}{8}$	63	75	91	109	123	145	185
1	57	68	82	98	111	131	166
$1\frac{1}{8}$	53	63	75	90	101	119	151
$1\frac{1}{4}$	49	58	69	83	93	109	138
$1\frac{3}{8}$	45	54	64	76	86	101	127
$1\frac{1}{2}$	42	51	59	71	80	94	119
$1\frac{3}{4}$	40	44	55	63	70	82	104
2	35	40	47	56	62	73	92
$2\frac{1}{4}$	32	36	42	50	56	66	83
$2\frac{1}{2}$	29	33	39	46	50	60	75
$2\frac{3}{4}$	26	30	36	42	46	55	67
3	24	28	33	39	43	51	64
$3\frac{1}{4}$	23	26	31	36	40	47	59
$3\frac{1}{2}$	21	24	29	34	38	44	55
$3\frac{3}{4}$	20	23	27	32	35	41	52
4	18	21	25	30	33	38	49
$4\frac{1}{4}$	17	20	24	......	......	......	......
$4\frac{1}{2}$	16	19	23	......	......	......	......

WEIGHT IN POUNDS OF 100 BOLTS WITH SQUARE HEADS AND NUTS.

One cubic foot weighing 480 lbs.

Length.	Diameter of Bolt, Inches.								
	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1
$1\frac{1}{2}$	4.0	6.8	10.6	15.0	23.9	40.5	70.0		
$1\frac{3}{4}$	4.4	7.3	11.3	16.1	25.1	42.7	73.1		
2	4.7	7.8	12.0	17.2	26.3	44.8	76.2		
$2\frac{1}{4}$	5.1	8.4	12.6	18.2	27.7	47.0	79.3		
$2\frac{1}{2}$	5.4	8.9	13.3	19.2	29.0	49.2	82.4	120.5	
$2\frac{3}{4}$	5.8	9.5	14.0	20.2	30.4	51.4	85.5	124.7	
3	6.1	10.0	14.7	21.2	31.8	53.5	88.7	128.9	185.0
$3\frac{1}{2}$	6.8	11.1	16.0	23.2	34.7	57.9	95.0	137.4	196.0
4	7.5	12.2	17.4	25.2	37.5	62.3	101.2	145.8	207.0
$4\frac{1}{2}$	8.2	13.2	18.7	27.2	40.2	66.7	107.5	159.2	218.0
5	8.9	14.3	20.0	29.1	43.0	71.0	113.7	167.7	229.0
$5\frac{1}{2}$	9.6	15.4	21.4	31.2	45.7	75.4	120.0	176.1	240.0
6	10.3	16.5	22.8	33.1	48.4	79.8	126.2	184.6	251.0
$6\frac{1}{2}$	11.0	17.6	24.1	35.1	51.2	84.1	132.5	193.0	262.0
7	11.7	18.6	25.9	37.1	54.0	88.5	138.7	201.4	273.0
$7\frac{1}{2}$	12.4	19.7	27.7	39.1	56.7	92.9	145.0	209.9	284.0
8	13.1	20.8	29.5	41.0	59.4	97.2	151.2	218.3	295.0
9	.....	......	33.1	45.0	64.8	106.0	163.7	240.2	317.0
10	.....	......	36.7	49.0	70.3	114.7	176.2	257.1	339.0
11	.....	......	40.4	53.0	75.8	123.5	188.7	273.9	360.0
12	.....	......	44.0	57.0	81.3	132.2	201.0	290.0	382.0
13	.....	......	......	......	86.7	140.7	213.4	307.7	404.0
14	.....	......	......	......	92.2	149.2	225.9	324.5	426.0
15	.....	......	......	......	97.7	157.6	238.3	341.4	448.0
16	.....	......	......	......	103.1	166.1	250.8	358.3	470.0
17	.....	......	......	......	108.6	174.6	263.2	375.2	492.0
18	.....	......	......	......	114.1	183.1	275.6	392.0	514.0
19	.....	......	......	......	119.5	191.5	288.1	408.9	536.0
20	.....	......	......	......	125.0	200.0	300.5	425.8	558.0
Per in. additional.	1.4	2.2	3.6	4.0	5.5	8.5	12.4	16.9	22.0

APPROXIMATE WEIGHT OF NUTS AND BOLT HEADS IN POUNDS.

Diam. of Bolt in Ins.	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$
Weight of hexagon nut and head	0.017	0.042	0.057	0.109	0.128	0.267	0.43
Weight of square nut and head	0.021	0.049	0.069	0.120	0.164	0.320	0.55
Diam. of Bolt in Ins.	$\frac{7}{8}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{2}$
Weight of hexagon nut and head	0.73	1.10	2.14	3.78	5.6	8.75	17.0
Weight of square nut and head	0.88	1.31	2.56	4.42	7.0	10.5	21.0

WEIGHTS AND SIZES OF SHEET LEAD.

Pounds per square foot	2½	3	3½	4	4½	5	6
Wire-gauge number. . .	19	18	17	16	15	14	13

Pounds per square foot	7	8	9	10	11	12
Wire-gauge number. . .	12	11	10	9	8	7

(A square foot of sheet lead $\frac{1}{16}$ of an inch thick weighs 4 pounds.)

APPROXIMATE WEIGHTS OF CAST-IRON SOIL-PIPE AND FITTINGS.

Standard.

Size, inches.	2	3	4	5	6	8	10	12
Pipe. . . . . pounds per foot	3½	4½	6½	8½	10	17	23	33
Crosses . . . . pounds each	5	10	12	16	24	. . . . .	45	. . . .
Double Y branch " "	8	11	18	26	37	. . . . .	. . . . .	. . . .
Double hubs. . . . . " "	3	4	6	8	10	16	26	. . . .
Eighth bends. . . . " "	3	4¾	6	8	11	24	32¾	. . . .
Half Y branches . " "	4½	6½	10	14	16	. . . . .	. . . . .	. . . .
Quarter bends. . . " "	4	5½	8	10	14½	34	41	. . . .
Reducers. . . . . " "	. . . .	3	4	6	8	9	. . . . .	. . . .
Sixth bends. . . . . " "	3	4¾	6	8	11	24	32¾	. . . .
Sleeves. . . . . " "	2½	4	5	6	7	. . . . .	. . . . .	. . . .
T branches. . . . . . " "	4	8	10	15	20	38	55	. . . .
Traps. . . . . " "	5½	10	19	26	35	. . . . .	. . . . .	. . . .
Y branches. . . . . . " "	5	9	13	18	25	42	70	. . . .
Size, inches.	. . . .	. . . .	. . . .	2×8	3×8	4×12	5×12	6×8
Offsets, pounds each.	. . . .	. . . .	. . . .	5	8	15	20	22

Extra Heavy.

Size, inches.	2	3	4	5	6	8	10	12
Pipe. . . . . pounds per foot.	5½	9½	13	17	20	34	45	54
Crosses . . . . pounds each	10	20	24	32	48	85	. . . . .	. . . .
Double Y branch. " "	12	20	32	42	60	. . . . .	. . . . .	. . . .
Double hubs. . . . . " "	4½	7	8	11	14	28	47	. . . .
Eighth bends. . . . " "	4¼	6¼	9½	12	16	35½	59½	. . . .
Half Y branches . " "	9	13	18	24	30	. . . . .	. . . . .	. . . .
Quarter bends. . . " "	6	8	12	15	20	44	74	. . . .
Reducers. . . . . " "	. . . .	4	6	8	11	16	. . . . .	. . . .
Sixth bends . . . . . " "	4¾	6¼	9½	12	16	35½	59½	. . . .
Sleeves . . . . " "	4	6	7	9	10	. . . . .	. . . . .	. . . .
T branches. . . . . . " "	7	13	20	25	34	50	104	. . . .
Traps. . . . . " "	9	18	28	45	68	. . . . .	. . . . .	. . . .
Y branches. . . . . . " "	10	15	25	32	45	85	151	. . . .
Size, inches.	. . . .	. . . .	. . . .	2×8	3×8	4×12	5×12	6×8
Offsets, pounds each.	. . . .	. . . .	. . . .	9	15	23	30	38

WEIGHT OF VARIOUS MATERIALS AS COMPARED WITH WATER WEIGHING 62.5 LBS.

The Specific Gravity of any substance is its weight compared with an equal bulk of pure water : a cubic foot of which weights 1,000 ounces, or 61½ pounds.

The specific gravity of lead, for instance, is 11.37, because a cubic foot of lead weights 11.37 times as much as a cubic foot of water.

Names of Substances.	Specific Gravity.
Aluminum cast	2.60
hammered	2.75
Amber	1.08
Anthracite	1.40–1.70
Asphaltum	1.10–1.20
Brass cast	8.40–8.70
rolled	8.57
Brick, common, hard	1.53–2.30
Cement, ground, loose	1.85
Charcoal	0.44
Cherry, dry	0.76–0.84
Clay, dry	1.80–2.60
Coal, bituminous	1.20–1.50
Coke, loose	0.55
Concrete	2.47
Copper cast	8.79
rolled	8.78–9.00
Diamond	3.52
Earth, humus	1.30–1.80
Glass, common window	2.64
Gneiss, common	2.40–2.70
Gold cast, pure, or 24 carat	19.28
pure, hammered	19.33
Granite	2.50–3.00
Gypsum, cast, dry	0.97
Hornblende	3.00
Ice	0.88–0.92
Iron cast	7.10–7.50
wrought	7.79
Ivory	1.82
Lead	11.37
Lime	2.30–3.20
Lime, slaked	1.30–1.40
Limestones	2.46–2.84
Magnesium	1.74
Mahogany	0.56–1.09
Maple, dry	0.70
Marble	2.52–2.85
Masonry, stone, dry	2.00–2.55
" brick, "	1.50–1.60
Mercury at 32° Fahr.	13.596
Mica	2.80
Nickel	8.8
Oak, dry	0.69–1.03
Petroleum at 59° Fahr.	0.80
Pine	0.35–0.60
Platinum cast	21.15
hammered	21.3–21.5
Quartz	2.5–2.80
Saltpetre, Chili	2.26
" Kali	1.95–2.08
Sand, fine, dry	1.40–1.65
" wet	1.90–2.05
" coarse	1.40–1.50
Sandstone	2.20–2.50
Silver cast	10.48
hammered	10.62
Slate	2.60–2.70
Snow, freshly fallen	0.19
Steel	7.26–7.86
Sulphur	1.93–2.07
Sodium	0.978
Tin cast	7.20
rolled	7.30
Water, pure rain or distilled, at 39° F.	1.00
Water, sea	1.03
Walnut, dry	0.60–0.81
Wax	0.95–0.98
Zinc cast	6.90
rolled	7.20

WEIGHT OF A CUBIC FOOT OF SUBSTANCES.

Names of Substances.	Average Weight, Pounds.
Aluminum	162
Anthracite, solid, of Pennsylvania	93
" broken, loose	54
" " moderately shaken	58
" heaped bushel, loose	(80)
Ash, American, white, dry	38
Asphaltum	87

WEIGHT OF SUBSTANCES—(*Continued*).

Names of Substances.	Average Weight, Pounds.
Brass (copper and zinc), cast	504
" rolled	524
Brick, best pressed	150
" common, hard	125
" soft, inferior	100
Brickwork, pressed brick	140
" ordinary	112
Cement, hydraulic, ground, loose, American Rosendale	56
" " " " " Louisville	50
" " " " English, Portland	90
Cherry, dry	42
Chestnut, dry	41
Clay, potters' dry	119
" in lump, loose	63
Coal, bituminous, solid	84
" " broken, loose	49
" " heaped bushel, loose	(74)
Coke, loose, of good coal	26.3
" " heaped bushel	(40)
Copper, cast	542
" rolled	548
Earth, common loam, dry, loose	76
" " " " moderately rammed	95
" as a soft, flowing mud	108
Ebony, dry	76
Elm, dry	35
Flint	162
Glass, common window	157
Gneiss, common	168
Gold, cast, pure, or 24 carat	1204
" pure, hammered	1217
Grain, at 60 lbs. per bushel	48
Granite	170
Gravel, about the same as sand, which see.	
Gypsum (plaster of Paris)	142
Hemlock, dry	25
Hickory, dry	53
Hornblende, black	203
Ice	58.7

WEIGHT OF SUBSTANCES—(*Continued*).

Names of Substances.	Average Weight, Pounds.
Iron, cast	450
" wrought, purest	485
" " average	480
Ivory	114
Lead	711
Lignum vitæ, dry	83
Lime, quick, ground, loose, or in small lumps	53
" " " " thoroughly shaken	75
" " " " per struck bushel	66
Limestones and marbles	168
" " " loose, in irregular fragments	96
Magnesium	109
Mahogany, Spanish, dry	53
" Honduras, dry	35
Maple, dry	45
Marbles, see Limestones.	
Masonry, of granite or limestone, well dressed	165
" " mortar rubble	154
" " dry " (well scabbled)	138
" " sandstone, well dressed	144
Mercury, at 32° Fahrenheit	849
Mica	183
Mortar, hardened	103
Mud, dry, close	80 to 110
Mud, wet, fluid, maximum	120
Oak, live, dry	59
Oak, white, dry	50
" other kinds	32 to 45
Petroleum	55
Pine, white, dry	25
" yellow, Northern	34
" " Southern	45
Platinum	1342
Quartz, common, pure	165
Rosin	69
Salt, coarse, Syracuse, N. Y.	45
" Liverpool, fine, for table use	49
Sand, of pure quartz, dry, loose	90 to 106
" well shaken	99 to 117

WEIGHT OF SUBSTANCES—(*Continued*).

Names of Substances.	Average Weight, Pounds.
Sand, perfectly wet	120 to 140
Sandstones, fit for building	151
Shales, red or black	162
Silver	655
Slate	175
Snow, freshly fallen	5 to 12
" moistened and compacted by rain	15 to 50
Spruce, dry	25
Steel	490
Sulphur	125
Sycamore, dry	37
Tar	62
Tin, cast	459
Turf or peat, dry, unpressed	20 to 30
Walnut, black, dry	38
Water, pure rain or distilled, at 60° Fahrenheit	$62\frac{1}{3}$
" sea	64
Wax, bees	60.5
Zinc or spelter	437.5

Green timbers usually weigh from one-fifth to one-half more than dry.

WEIGHT OF DIFFERENT MATERIALS.

	Pounds.
1 barrel of lime	200 to 230
1 " " cement (hydraulic or Rosendale)	300
1 " " " (Portland)	400
1 " " " (Scotch, Roman)	350
1 " " fire-clay (American)	300
1 " " " (English)	350
1 " " brick-dust	350
1 " " marble-dust	350
1 " " plaster, California	260
1 " " " Wotherspoon (Eastern)	275
1 " " " (ground gypsum or land)	320

Fire-brick $6\frac{1}{2}$ to 7 pounds each.

Approximate Weight of Roof Coverings.

Material.	Weight in pounds per square of roof.
Ash sheathing, 1 inch thick	500
Chestnut sheathing, 1 inch thick	400
Copper, 16 ounce, standing seam	150
Felt and asphalt, without sheathing	150
Felt and gravel, without sheathing	800 to 1000
Glass with skylight frame $\frac{3}{16}$ inch to $\frac{1}{2}$ inch thick	250 to 700
Hemlock sheathing, 1 inch thick	200
Iron, corrugated, No. 20, without sheathing	250
Iron, galvanized, flat	100 to 350
Lath and plaster ceiling (ordinary)	600 to 800
Lead, about $\frac{1}{8}$ inch thick	600 to 800
Maple sheathing, 1 inch thick	400
Mackite, 1 inch thick, with plaster	1000
Neponset roofing felt, 2 layers	50
Oak sheathing, 1 inch thick	500
Slate, $\frac{1}{4}$ inch thick	900
Slate, $\frac{3}{16}$ inch thick	675
Slate, $\frac{1}{8}$ inch thick	450
Shingles, 6 inches × 18 inches, 6 inches to the weather	200
Sheet iron, $\frac{1}{16}$ inch thick	300
Sheet iron, $\frac{1}{16}$ inch thick, with laths	400
Spruce sheathing, 1 inch thick	250
Slag roofing, four ply	400
Tiles (plain) $10\frac{1}{2}$ inches × $6\frac{1}{4}$ inches × $\frac{5}{8}$ inches, $5\frac{1}{2}$ inches to weather	1800
Tiles (Spanish) $14\frac{1}{2}$ inches × $10\frac{1}{2}$ inches, $7\frac{1}{2}$ inches to weather	850
Tiles, plain with mortar	2000 to 3000
Terne plate (tin), IC, without sheathing	50
Terne plate (tin), IX, without sheathing	65
White pine sheathing, 1 inch thick	250
Yellow pine sheathing, 1 inch thick	400

ANGLES OF ROOFS AS COMMONLY USED.

Proportion of Rise to Span.	Angle.		Length of Rafter to Rise.	Proportion of Rise to Span.	Angle.		Length of Rafter to Rise.
	Deg.	Min.			Deg.	Min.	
$\frac{1}{2}$	45	......	1.4142	$\frac{1}{4}$	26	34	2.2361
$\frac{1}{3}$	33	41	1.8028	$\frac{1}{5}$	21	48	2.6926
$\frac{1}{2\sqrt{3}}$	30	......	2.0000	$\frac{1}{6}$	18	26	3.1623

WEIGHTS OF FLAT ROLLED STEEL.

PER LINEAL FOOT.

One Cubic Foot Weighing 489.6 Lbs.

Thickness in Inches.	1″	1¼″	1½″	1¾″	2″	2¼″	2½″	2¾″	12″
$\frac{3}{16}$	.638	.797	.957	1.11	1.28	1.44	1.59	1.75	7.65
$\frac{1}{4}$	.850	1.06	1.28	1.49	1.70	1.91	2.12	2.34	10.20
$\frac{5}{16}$	1.06	1.33	1.59	1.86	2.12	2.39	2.65	2.92	12.75
$\frac{3}{8}$	1.28	1.59	1.92	2.23	2.55	2.87	3.19	3.51	15.30
$\frac{7}{16}$	1.49	1.86	2.23	2.60	2.98	3.35	3.72	4.09	17.85
$\frac{1}{2}$	1.70	2.12	2.55	2.98	3.40	3.83	4.25	4.67	20.40
$\frac{9}{16}$	1.92	2.39	2.87	3.35	3.83	4.30	4.78	5.26	22.95
$\frac{5}{8}$	2.12	2.65	3.19	3.72	4.25	4.78	5.31	5.84	25.50
$\frac{11}{16}$	2.34	2.92	3.51	4.09	4.67	5.26	5.84	6.43	28.05
$\frac{3}{4}$	2.55	3.19	3.83	4.47	5.10	5.75	6.38	7.02	30.60
$\frac{13}{16}$	2.76	3.45	4.14	4.84	5.53	6.21	6.90	7.60	33.15
$\frac{7}{8}$	2.98	3.72	4.47	5.20	5.95	6.69	7.44	8.18	35.70
$\frac{15}{16}$	3.19	3.99	4.78	5.58	6.38	7.18	7.97	8.77	38.25
1	3.40	4.25	5.10	5.95	6.80	7.65	8.50	9.35	40.80
$1\frac{1}{16}$	3.61	4.52	5.42	6.32	7.22	8.13	9.03	9.93	43.35
$1\frac{1}{8}$	3.83	4.78	5.74	6.70	7.65	8.61	9.57	10.52	45.90
$1\frac{3}{16}$	4.04	5.05	6.06	7.07	8.08	9.09	10.10	11.11	48.45
$1\frac{1}{4}$	4.25	5.31	6.38	7.44	8.50	9.57	10.63	11.69	51.00
$1\frac{5}{16}$	4.46	5.58	6.69	7.81	8.93	10.04	11.16	12.27	53.55
$1\frac{3}{8}$	4.67	5.84	7.02	8.18	9.35	10.52	11.69	12.85	56.10
$1\frac{7}{16}$	4.89	6.11	7.34	8.56	9.78	11.00	12.22	13.44	58.65
$1\frac{1}{2}$	5.10	6.38	7.65	8.93	10.20	11.48	12.75	14.03	61.20
$1\frac{9}{16}$	5.32	6.64	7.97	9.30	10.63	11.95	13.28	14.61	63.75
$1\frac{5}{8}$	5.52	6.90	8.29	9.67	11.05	12.43	13.81	15.19	66.30
$1\frac{11}{16}$	5.74	7.17	8.61	10.04	11.47	12.91	14.34	15.78	68.85
$1\frac{3}{4}$	5.95	7.44	8.93	10.42	11.90	13.40	14.88	16.37	71.40
$1\frac{13}{16}$	6.16	7.70	9.24	10.79	12.33	13.86	15.40	16.95	73.95
$1\frac{7}{8}$	6.38	7.97	9.57	11.15	12.75	14.34	15.94	17.53	76.50
$1\frac{15}{16}$	6.59	8.24	9.88	11.53	13.18	14.83	16.47	18.12	79.05
2	6.80	8.50	10.20	11.90	13.60	15.30	17.00	18.70	81.60

WEIGHTS OF FLAT ROLLED STEEL—(*Continued*).

PER LINEAL FOOT.

Thickness in Inches.	3″	3¼″	3½″	3¾″	4″	4¼″	4½″	4¾″	12″
$\frac{3}{16}$	1.91	2.07	2.23	2.39	2.55	2.71	2.87	3.03	7.65
$\frac{1}{4}$	2.55	2.76	2.98	3.19	3.40	3.61	3.83	4.04	10.20
$\frac{5}{16}$	3.19	3.45	3.72	3.99	4.25	4.52	4.78	5.05	12.75
$\frac{3}{8}$	3.83	4.15	4.47	4.78	5.10	5.42	5.74	6.06	15.30
$\frac{7}{16}$	4.46	4.83	5.20	5.58	5.95	6.32	6.70	7.07	17.85
$\frac{1}{2}$	5.10	5.53	5.95	6.38	6.80	7.22	7.65	8.08	20.40
$\frac{9}{16}$	5.74	6.22	6.70	7.17	7.65	8.13	8.61	9.09	22.95
$\frac{5}{8}$	6.38	6.91	7.44	7.97	8.50	9.03	9.57	10.10	25.50
$\frac{11}{16}$	7.02	7.60	8.18	8.76	9.35	9.93	10.52	11.11	28.05
$\frac{3}{4}$	7.65	8.29	8.93	9.57	10.20	10.84	11.48	12.12	30.60
$\frac{13}{16}$	8.29	8.98	9.67	10.36	11.05	11.74	12.43	13.12	33.15
$\frac{7}{8}$	8.93	9.67	10.41	11.16	11.90	12.65	13.39	14.13	35.70
$\frac{15}{16}$	9.57	10.36	11.16	11.95	12.75	13.55	14.34	15.14	38.25
1	10.20	11.05	11.90	12.75	13.60	14.45	15.30	16.15	40.80
$1\frac{1}{16}$	10.84	11.74	12.65	13.55	14.45	15.35	16.26	17.16	43.35
$1\frac{1}{8}$	11.48	12.43	13.39	14.34	15.30	16.26	17.22	18.17	45.90
$1\frac{3}{16}$	12.12	13.12	14.13	15.14	16.15	17.16	18.17	19.18	48.45
$1\frac{1}{4}$	12.75	13.81	14.87	15.94	17.00	18.06	19.13	20.19	51.00
$1\frac{5}{16}$	13.39	14.50	15.62	16.74	17.85	18.96	20.08	21.20	53.55
$1\frac{3}{8}$	14.03	15.20	16.36	17.53	18.70	19.87	21.04	22.21	56.10
$1\frac{7}{16}$	14.66	15.88	17.10	18.33	19.55	20.77	21.99	23.22	58.65
$1\frac{1}{2}$	15.30	16.58	17.85	19.13	20.40	21.68	22.95	24.23	61.20
$1\frac{9}{16}$	15.94	17.27	18.60	19.92	21.25	22.58	23.91	25.24	63.75
$1\frac{5}{8}$	16.58	17.96	19.34	20.72	22.10	23.48	24.87	26.25	66.30
$1\frac{11}{16}$	17.22	18.65	20.08	21.51	22.95	24.38	25.82	27.26	68.85
$1\frac{3}{4}$	17.85	19.34	20.83	22.32	23.80	25.29	26.78	28.27	71.40
$1\frac{13}{16}$	18.49	20.03	21.57	23.11	24.65	26.19	27.73	29.27	73.95
$1\frac{7}{8}$	19.13	20.72	22.31	23.91	25.50	27.10	28.69	30.28	76.50
$1\frac{15}{16}$	19.77	21.41	23.06	24.70	26.35	28.00	29.64	31.29	79.05
2	20.40	22.10	23.80	25.50	27.20	28.90	30.60	32.30	81.60

WEIGHTS OF FLAT ROLLED STEEL—(*Continued*).

PER LINEAL FOOT.

Thickness in Inches.	5″	$5\frac{1}{4}$″	$5\frac{1}{2}$″	$5\frac{3}{4}$″	6″	$6\frac{1}{4}$″	$6\frac{1}{2}$″	$6\frac{3}{4}$″	12″
$\frac{3}{16}$	3.19	3.35	3.51	3.67	3.83	3.99	4.14	4.30	7.65
$\frac{1}{4}$	4.25	4.46	4.67	4.89	5.10	5.31	5.53	5.74	10.20
$\frac{5}{16}$	5.31	5.58	5.84	6.11	6.38	6.64	6.90	7.17	12.75
$\frac{3}{8}$	6.38	6.69	7.02	7.34	7.65	7.97	8.29	8.61	15.30
$\frac{7}{16}$	7.44	7.81	8.18	8.56	8.93	9.29	9.67	10.04	17.85
$\frac{1}{2}$	8.50	8.93	9.35	9.77	10.20	10.63	11.05	11.48	20.40
$\frac{9}{16}$	9.57	10.04	10.52	11.00	11.48	11.95	12.43	12.91	22.95
$\frac{5}{8}$	10.63	11.16	11.69	12.22	12.75	13.28	13.81	14.34	25.50
$\frac{11}{16}$	11.69	12.27	12.85	13.44	14.03	14.61	15.20	15.78	28.05
$\frac{3}{4}$	12.75	13.39	14.03	14.67	15.30	15.94	16.58	17.22	30.60
$\frac{13}{16}$	13.81	14.50	15.19	15.88	16.58	17.27	17.95	18.65	33.15
$\frac{7}{8}$	14.87	15.62	16.36	17.10	17.85	18.60	19.34	20.08	35.70
$\frac{15}{16}$	15.94	16.74	17.53	18.33	19.13	19.92	20.72	21.51	38.25
1	17.00	17.85	18.70	19.55	20.40	21.25	22.10	22.95	40.80
$1\frac{1}{16}$	18.06	18.96	19.87	20.77	21.68	22.58	23.48	24.39	43.35
$1\frac{1}{8}$	19.13	20.08	21.04	21.99	22.95	23.91	24.87	25.82	45.90
$1\frac{3}{16}$	20.19	21.20	22.21	23.22	24.23	25.23	26.24	27.25	48.45
$1\frac{1}{4}$	21.25	22.32	23.38	24.44	25.50	26.56	27.62	28.69	51.00
$1\frac{5}{16}$	22.32	23.43	24.54	25.66	26.78	27.90	29.01	30.12	53.55
$1\frac{3}{8}$	23.38	24.54	25.71	26.88	28.05	29.22	30.39	31.56	56.10
$1\frac{7}{16}$	24.44	25.66	26.88	28.10	29.33	30.55	31.77	32.99	58.65
$1\frac{1}{2}$	25.50	26.78	28.05	29.33	30.60	31.88	33.15	34.43	61.20
$1\frac{9}{16}$	26.57	27.89	29.22	30.55	31.88	33.20	34.53	35.86	63.75
$1\frac{5}{8}$	27.63	29.01	30.39	31.77	33.15	34.53	35.91	37.29	66.30
$1\frac{11}{16}$	28.69	30.12	31.55	32.99	34.43	35.86	37.30	38.73	68.85
$1\frac{3}{4}$	29.75	31.24	32.73	34.22	35.70	37.19	38.68	40.17	71.40
$1\frac{13}{16}$	30.81	32.35	33.89	35.43	36.98	38.52	40.05	41.60	73.95
$1\frac{7}{8}$	31.87	33.47	35.06	36.65	38.25	39.85	41.44	43.03	76.50
$1\frac{15}{16}$	32.94	34.59	36.23	37.88	39.53	41.17	42.82	44.46	79.05
2	34.00	35.70	37.40	39.10	40.80	42.50	44.20	45.90	81.60

WEIGHTS OF FLAT ROLLED STEEL—(*Continued*).

PER LINEAL FOOT.

Thickness in Inches.	7″	7¼″	7½″	7¾″	8″	8¼″	8½″	8¾″	12″
$\frac{3}{16}$	4.46	4.62	4.78	4.94	5.10	5.26	5.42	5.58	7.65
$\frac{1}{4}$	5.95	6.16	6.36	6.58	6.80	7.01	7.22	7.43	10.20
$\frac{5}{16}$	7.44	7.70	7.97	8.23	8.50	8.76	9.03	9.29	12.75
$\frac{3}{8}$	8.93	9.25	9.57	9.88	10.20	10.52	10.84	11.16	15.30
$\frac{7}{16}$	10.41	10.78	11.16	11.53	11.90	12.27	12.64	13.02	17.85
$\frac{1}{2}$	11.90	12.32	12.75	13.18	13.60	14.03	14.44	14.87	20.40
$\frac{9}{16}$	13.39	13.86	14.34	14.82	15.30	15.78	16.26	16.74	22.95
$\frac{5}{8}$	14.87	15.40	15.94	16.47	17.00	17.53	18.06	18.59	25.50
$\frac{11}{16}$	16.36	16.94	17.53	18.12	18.70	19.28	19.86	20.45	28.05
$\frac{3}{4}$	17.85	18.49	19.13	19.77	20.40	21.04	21.68	22.32	30.60
$\frac{13}{16}$	19.34	20.03	20.72	21.41	22.10	22.79	23.48	24.17	33.15
$\frac{7}{8}$	20.83	21.57	22.32	23.05	23.80	24.55	25.30	26.04	35.70
$\frac{15}{16}$	22.32	23.11	23.91	24.70	25.50	26.30	27.10	27.89	38.25
1	23.80	24.65	25.50	26.35	27.20	28.05	28.90	29.75	40.80
$1\frac{1}{16}$	25.29	26.19	27.10	28.00	28.90	29.80	30.70	31.61	43.35
$1\frac{1}{8}$	26.78	27.73	28.68	29.64	30.60	31.56	32.52	33.47	45.90
$1\frac{3}{16}$	28.26	29.27	30.28	31.29	32.30	33.31	34.32	35.33	48.45
$1\frac{1}{4}$	29.75	30.81	31.88	32.94	34.00	35.06	36.12	37.20	51.00
$1\frac{5}{16}$	31.23	32.35	33.48	34.59	35.70	36.81	37.93	39.05	53.55
$1\frac{3}{8}$	32.72	33.89	35.06	36.23	37.40	38.57	39.74	40.91	56.10
$1\frac{7}{16}$	34.21	35.44	36.66	37.88	39.10	40.32	41.54	42.77	58.65
$1\frac{1}{2}$	35.70	36.98	38.26	39.53	40.80	42.08	43.35	44.63	61.20
$1\frac{9}{16}$	37.19	38.51	39.84	41.17	42.50	43.83	45.16	46.49	63.75
$1\frac{5}{8}$	38.67	40.05	41.44	42.82	44.20	45.58	46.96	48.34	66.30
$1\frac{11}{16}$	40.16	41.59	43.03	44.47	45.90	47.33	48.76	50.20	68.85
$1\frac{3}{4}$	41.65	43.14	44.63	46.12	47.60	49.09	50.58	52.07	71.40
$1\frac{13}{16}$	43.14	44.68	46.22	47.76	49.30	50.84	52.38	53.92	73.95
$1\frac{7}{8}$	44.63	46.22	47.82	49.40	51.00	52.60	54.20	55.79	76.50
$1\frac{15}{16}$	46.12	47.76	49.41	51.05	52.70	54.35	56.00	57.64	79.05
2	47.60	49.30	51.00	52.70	54.40	56.10	57.80	59.50	81.60

WEIGHTS OF FLAT ROLLED STEEL—(*Continued*).

PER LINEAL FOOT.

Thickness in Inches.	9″	9¼″	9½″	9¾″	10″	10¼″	10½″	10¾″	12″
3/16	5.74	5.90	6.06	6.22	6.38	6.54	6.70	6.86	7.65
1/4	7.65	7.86	8.08	8.29	8.50	8.71	8.92	9.14	10.20
5/16	9.56	9.83	10.10	10.36	10.62	10.89	11.16	11.42	12.75
3/8	11.48	11.80	12.12	12.44	12.75	13.07	13.39	13.71	15.30
7/16	13.40	13.76	14.14	14.51	14.88	15.25	15.62	15.99	17.85
1/2	15.30	15.73	16.16	16.58	17.00	17.42	17.85	18.28	20.40
9/16	17.22	17.69	18.18	18.65	19.14	19.61	20.08	20.56	22.95
5/8	19.13	19.65	20.19	20.72	21.25	21.78	22.32	22.85	25.50
11/16	21.04	21.62	22.21	22.79	23.38	23.96	24.54	25.13	28.05
3/4	22.96	23.59	24.23	24.86	25.50	26.14	26.78	27.42	30.60
13/16	24.86	25.55	26.24	26.94	27.62	28.32	29.00	29.69	33.15
7/8	26.78	27.52	28.26	29.01	29.75	30.50	31.24	31.98	35.70
15/16	28.69	29.49	30.28	31.08	31.88	32.67	33.48	34.28	38.25
1	30.60	31.45	32.30	33.15	34.00	34.85	35.70	36.55	40.80
1 1/16	32.52	33.41	34.32	35.22	36.12	37.03	37.92	38.83	43.35
1 1/8	34.43	35.38	36.34	37.29	38.25	39.21	40.17	41.12	45.90
1 3/16	36.34	37.35	38.36	39.37	40.38	41.39	42.40	43.40	48.45
1 1/4	38.26	39.31	40.37	41.44	42.50	43.56	44.63	45.69	51.00
1 5/16	40.16	41.28	42.40	43.52	44.64	45.75	46.86	47.97	53.55
1 3/8	42.08	43.25	44.41	45.58	46.75	47.92	49.08	50.25	56.10
1 7/16	44.00	45.22	46.44	47.66	48.88	50.10	51.32	52.54	58.65
1 1/2	45.90	47.18	48.45	49.73	51.00	52.28	53.55	54.83	61.20
1 9/16	47.82	49.14	50.48	51.80	53.14	54.46	55.78	57.11	63.75
1 5/8	49.73	51.10	52.49	53.87	55.25	56.63	58.02	59.40	66.30
1 11/16	51.64	53.07	54.51	55.94	57.38	58.81	60.24	61.68	68.85
1 3/4	53.56	55.04	56.53	58.01	59.50	60.99	62.48	63.97	71.40
1 13/16	55.46	57.00	58.54	60.09	61.62	63.17	64.70	66.24	73.95
1 7/8	57.38	58.97	60.56	62.16	63.75	65.35	66.94	68.53	76.50
1 15/16	59.29	60.94	62.58	64.23	65.88	67.52	69.18	70.83	79.05
2	61.20	62.90	64.60	66.30	68.00	69.70	71.40	73.10	81.60

WEIGHTS OF FLAT ROLLED STEEL—(*Continued*).

PER LINEAL FOOT.

Thickness in Inches.	11″	$11\frac{1}{4}$″	$11\frac{1}{2}$″	$11\frac{3}{4}$″	12″	$12\frac{1}{4}$″	$12\frac{1}{2}$″	$12\frac{3}{4}$″
$\frac{3}{16}$	7.02	7.17	7.32	7.49	7.65	7.82	7.98	8.13
$\frac{1}{4}$	9.34	9.57	9.78	10.00	10.20	10.42	10.63	10.84
$\frac{5}{16}$	11.68	11.95	12.22	12.49	12.75	13.01	13.28	13.55
$\frac{3}{8}$	14.03	14.35	14.68	14.99	15.30	15.62	15.94	16.26
$\frac{7}{16}$	16.36	16.74	17.12	17.49	17.85	18.23	18.60	18.97
$\frac{1}{2}$	18.70	19.13	19.55	19.97	20.40	20.82	21.25	21.67
$\frac{9}{16}$	21.02	21.51	22.00	22.48	22.95	23.43	23.90	24.39
$\frac{5}{8}$	23.38	23.91	24.44	24.97	25.50	26.03	26.56	27.09
$\frac{11}{16}$	25.70	26.30	26.88	27.47	28.05	28.64	29.22	29.80
$\frac{3}{4}$	28.05	28.68	29.33	29.97	30.60	31.25	31.88	32.52
$\frac{13}{16}$	30.40	31.08	31.76	32.46	33.15	33.83	34.53	35.22
$\frac{7}{8}$	32.72	33.47	34.21	34.95	35.70	36.44	37.19	37.93
$\frac{15}{16}$	35.06	35.86	36.66	37.46	38.25	39.05	39.84	40.64
1	37.40	38.25	39.10	39.95	40.80	41.65	42.50	43.35
$1\frac{1}{16}$	39.74	40.64	41.54	42.54	43.35	44.25	45.16	46.06
$1\frac{1}{8}$	42.08	43.04	44.00	44.94	45.90	46.86	47.82	48.77
$1\frac{3}{16}$	44.42	45.42	46.44	47.45	48.45	49.46	50.46	51.48
$1\frac{1}{4}$	46.76	47.82	48.88	49.94	51.00	52.06	53.12	54.19
$1\frac{5}{16}$	49.08	50.20	51.32	52.44	53.55	54.67	55.78	56.90
$1\frac{3}{8}$	51.42	52.59	53.76	54.93	56.10	57.27	58.44	59.60
$1\frac{7}{16}$	53.76	54.99	56.21	57.43	58.65	59.87	60.10	62.32
$1\frac{1}{2}$	56.10	57.37	58.65	59.93	61.20	62.48	63.75	65.03
$1\frac{9}{16}$	58.42	59.76	61.10	62.43	63.75	65.08	66.40	67.74
$1\frac{5}{8}$	60.78	62.16	63.54	64.92	66.30	67.68	69.06	70.44
$1\frac{11}{16}$	63.10	64.55	65.98	67.42	68.85	70.29	71.72	73.15
$1\frac{3}{4}$	65.45	66.93	68.43	69.92	71.40	72.90	74.38	75.87
$1\frac{13}{16}$	67.80	69.33	70.86	72.41	73.95	75.48	77.03	78.57
$1\frac{7}{8}$	70.12	71.72	73.31	74.90	76.50	78.09	79.69	81.28
$1\frac{15}{16}$	72.46	74.11	75.76	77.41	79.05	80.70	82.34	83.99
2	74.80	76.50	78.20	79.90	81.60	83.30	85.00	86.70

The weights for 12-inch width are repeated on each page to facilitate making the additions necessary to obtain the weights of plates wider than 12 inches. Thus, to find the weight of $15\frac{1}{4} \times \frac{7}{8}$ in. add the weights to be found in the same line for $3\frac{1}{4} \times \frac{7}{8}$ and $12 \times \frac{7}{8} = 10.41 + 35.70 = 46.11$ lbs.

WEIGHTS AND AREAS OF SQUARE AND ROUND BARS AND CIRCUMFERENCES OF ROUND BARS.

One cubic foot of steel weighing 489.6 lbs.

Thickness or Diameter in Inches.	Weight of □ Bar One Foot Long.	Weight of ○ Bar One Foot Long.	Area of □ Bar in Square Inches.	Area of ○ Bar in Square Inches.	Circumference of ○ Bar in Inches.
0					
$\frac{1}{16}$	.013	.010	.0039	.0031	.1963
$\frac{1}{8}$	.053	.042	.0156	.0123	.3927
$\frac{3}{16}$	.119	.094	.0352	.0276	.5890
$\frac{1}{4}$	.212	.167	.0625	.0491	.7854
$\frac{5}{16}$	.333	.261	.0977	.0767	.9817
$\frac{3}{8}$	.478	.375	.1406	.1104	1.1781
$\frac{7}{16}$	.651	.511	.1914	.1503	1.3744
$\frac{1}{2}$	.850	.667	.2500	.1963	1.5708
$\frac{9}{16}$	1.076	.845	.3164	.2485	1.7671
$\frac{5}{8}$	1.328	1.043	.3906	.3068	1.9635
$\frac{11}{16}$	1.608	1.262	.4727	.3712	2.1598
$\frac{3}{4}$	1.913	1.502	.5625	.4418	2.3562
$\frac{13}{16}$	2.245	1.763	.6602	.5185	2.5525
$\frac{7}{8}$	2.603	2.044	.7656	.6013	2.7489
$\frac{15}{16}$	2.989	2.347	.8789	.6903	2.9452
1	3.400	2.670	1.0000	.7854	3.1416
$\frac{1}{16}$	3.838	3.014	1.1289	.8866	3.3379
$\frac{1}{8}$	4.303	3.379	1.2656	.9940	3.5343
$\frac{3}{16}$	4.795	3.766	1.4102	1.1075	3.7306
$\frac{1}{4}$	5.312	4.173	1.5625	1.2272	3.9270
$\frac{5}{16}$	5.857	4.600	1.7227	1.3530	4.1233
$\frac{3}{8}$	6.428	5.049	1.8906	1.4849	4.3197
$\frac{7}{16}$	7.026	5.518	2.0664	1.6230	4.5160
$\frac{1}{2}$	7.650	6.008	2.2500	1.7671	4.7124
$\frac{9}{16}$	8.301	6.520	2.4414	1.9175	4.9087
$\frac{5}{8}$	8.978	7.051	2.6406	2.0739	5.1051
$\frac{11}{16}$	9.682	7.604	2.8477	2.2365	5.3014
$\frac{3}{4}$	10.41	8.178	3.0625	2.4053	5.4978
$\frac{13}{16}$	11.17	8.773	3.2852	2.5802	5.6941
$\frac{7}{8}$	11.95	9.388	3.5156	2.7612	5.8905
$\frac{15}{16}$	12.76	10.02	3.7539	2.9483	6.0868

WEIGHTS AND AREAS OF SQUARE AND ROUND BARS AND CIRCUMFERENCES OF ROUND BARS—(*Continued*).

Thickness or Diameter in Inches.	Weight of □ Bar One Foot Long.	Weight of ○ Bar One Foot Long.	Area of □ Bar in Square Inches.	Area of ○ Bar in Square Inches.	Circumference of ○ Bar in Inches.
2	13.60	10.68	4.0000	3.1416	6.2832
1/16	14.46	11.36	4.2539	3.3410	6.4795
1/8	15.35	12.06	4.5156	3.5466	6.6759
3/16	16.27	12.78	4.7852	3.7583	6.8722
1/4	17.22	13.52	5.0625	3.9761	7.0686
5/16	18.19	14.28	5.3477	4.2000	7.2649
3/8	19.18	15.07	5.6406	4.4301	7.4613
7/16	20.20	15.86	5.9414	4.6664	7.6576
1/2	21.25	16.69	6.2500	4.9087	7.8540
9/16	22.33	17.53	6.5664	5.1572	8.0503
5/8	23.43	18.40	6.8906	5.4119	8.2467
11/16	24.56	19.29	7.2227	5.6727	8.4430
3/4	25.71	20.20	7.5625	5.9396	8.6394
13/16	26.90	21.12	7.9102	6.2126	8.8357
7/8	28.10	22.07	8.2656	6.4918	9.0321
15/16	29.34	23.04	8.6289	6.7771	9.2284
3	30.60	24.03	9.0000	7.0686	9.4248
1/16	31.89	25.04	9.3789	7.3662	9.6211
1/8	33.20	26.08	9.7656	7.6699	9.8175
3/16	34.55	27.13	10.160	7.9798	10.014
1/4	35.92	28.20	10.563	8.2958	10.210
5/16	37.31	29.30	10.973	8.6179	10.407
3/8	38.73	30.42	11.391	8.9462	10.603
7/16	40.18	31.56	11.816	9.2806	10.799
1/2	41.65	32.71	12.250	9.6211	10.996
9/16	43.14	33.90	12.691	9.9678	11.192
5/8	44.68	35.09	13.141	10.321	11.388
11/16	46.24	36.31	13.598	10.680	11.585
3/4	47.82	37.56	14.063	11.045	11.781
13/16	49.42	38.81	14.535	11.416	11.977
7/8	51.05	40.10	15.016	11.793	12.174
15/16	52.71	41.40	15.504	12.177	12.370

WEIGHTS AND AREAS OF SQUARE AND ROUND BARS AND CIRCUMFERENCES OF ROUND BARS—(*Continued*).

Thickness or Diameter in Inches.	Weight of □ Bar One Foot Long.	Weight of ○ Bar One Foot Long.	Area of □ Bar in Square Inches.	Area of ○ Bar in Square Inches.	Circumference of ○ Bar in Inches.
4	54.40	42.73	16.000	12.566	12.566
$\frac{1}{16}$	56.11	44.07	16.504	12.962	12.763
$\frac{1}{8}$	57.85	45.44	17.016	13.364	12.959
$\frac{3}{16}$	59.62	46.83	17.535	13.772	13.155
$\frac{1}{4}$	61.41	48.24	18.063	14.186	13.352
$\frac{5}{16}$	63.23	49.66	18.598	14.607	13.548
$\frac{3}{8}$	65.08	51.11	19.141	15.033	13.744
$\frac{7}{16}$	66.95	52.58	19.691	15.466	13.941
$\frac{1}{2}$	68.85	54.07	20.250	15.904	14.137
$\frac{9}{16}$	70.78	55.59	20.816	16.349	14.334
$\frac{5}{8}$	72.73	57.12	21.391	16.800	14.530
$\frac{11}{16}$	74.70	58.67	21.973	17.257	14.726
$\frac{3}{4}$	76.71	60.25	22.563	17.721	14.923
$\frac{13}{16}$	78.74	61.84	23.160	18.190	15.119
$\frac{7}{8}$	80.81	63.46	23.766	18.665	15.315
$\frac{15}{16}$	82.89	65.10	24.379	19.147	15.512
5	85.00	66.76	25.000	19.635	15.708
$\frac{1}{16}$	87.14	68.44	25.629	20.129	15.904
$\frac{1}{8}$	89.30	70.14	26.266	20.629	16.101
$\frac{3}{16}$	91.49	71.86	26.910	21.135	16.297
$\frac{1}{4}$	93.72	73.60	27.563	21.648	16.493
$\frac{5}{16}$	95.96	75.37	28.223	22.166	16.690
$\frac{3}{8}$	98.23	77.15	28.891	22.691	16.886
$\frac{7}{16}$	100.5	78.95	29.566	23.221	17.082
$\frac{1}{2}$	102.8	80.77	30.250	23.758	17.279
$\frac{9}{16}$	105.2	82.62	30.941	24.301	17.475
$\frac{5}{8}$	107.6	84.49	31.641	24.850	17.671
$\frac{11}{16}$	110.0	86.38	32.348	25.406	17.868
$\frac{3}{4}$	112.4	88.29	33.063	25.967	18.064
$\frac{13}{16}$	114.9	90.22	33.785	26.535	18.261
$\frac{7}{8}$	117.4	92.17	34.516	27.109	18.457
$\frac{15}{16}$	119.9	94.14	35.254	27.688	18.653

WEIGHTS AND AREAS OF SQUARE AND ROUND BARS AND CIRCUMFERENCES OF ROUND BARS—(*Continued*).

Thickness or Diameter in Inches.	Weight of □ Bar One Foot Long	Weight of ○ Bar One Foot Long.	Area of □ Bar in Square Inches.	Area of ○ Bar in Square Inches.	Circumference of ○ Bar in Inches.
6	122.4	96.14	36.000	28.274	18.850
1/16	125.0	98.14	36.754	28.866	19.046
1/8	127.6	100.2	37.516	29.465	19.242
3/16	130.2	102.2	38.285	30.069	19.439
1/4	132.8	104.3	39.063	30.680	19.635
5/16	135.5	106.4	39.848	31.296	19.831
3/8	138.2	108.5	40.641	31.919	20.028
7/16	140.9	110.7	41.441	32.548	20.224
1/2	143.6	112.8	42.250	33.183	20.420
9/16	146.5	114.9	43.066	33.824	20.617
5/8	149.2	117.2	43.891	34.472	20.813
11/16	152.1	119.4	44.723	35.125	21.009
3/4	154.9	121.7	45.563	35.785	21.206
13/16	157.8	123.9	46.410	36.450	21.402
7/8	160.8	126.2	47.266	37.122	21.598
15/16	163.6	128.5	48.129	37.800	21.795
7	166.6	130.9	49.000	38.485	21.991
1/16	169.6	133.2	49.879	39.175	22.187
1/8	172.6	135.6	50.766	39.871	22.384
3/16	175.6	137.9	51.660	40.574	22.580
1/4	178.7	140.4	52.563	41.282	22.777
5/16	181.8	142.8	53.473	41.997	22.973
3/8	184.9	145.3	54.391	42.718	23.169
7/16	188.1	147.7	55.316	43.445	23.366
1/2	191.3	150.2	56.250	44.179	23.562
9/16	194.4	152.7	57.191	44.918	23.758
5/8	197.7	155.2	58.141	45.664	23.955
11/16	200.9	157.8	59.098	46.415	24.151
3/4	204.2	160.3	60.063	47.173	24.347
13/16	207.6	163.0	61.035	47.937	24.544
7/8	210.8	165.6	62.016	48.707	24.740
15/16	214.2	168.2	63.004	49.483	24.936

WEIGHTS AND AREAS OF SQUARE AND ROUND BARS AND CIRCUMFERENCES OF ROUND BARS—(*Continued*).

Thickness or Diameter in Inches.	Weight of □ Bar One Foot Long.	Weight of ○ Bar One Foot Long.	Area of □ Bar in Square Inches.	Area of ○ Bar in Square Inches.	Circumference of ○ Bar in Inches.
8	217.6	171.0	64.000	50.265	25.133
$\frac{1}{16}$	221.0	173.6	65.004	51.054	25.329
$\frac{1}{8}$	224.5	176.3	66.016	51.849	25.525
$\frac{3}{16}$	228.0	179.0	67.035	52.649	25.722
$\frac{1}{4}$	231.4	181.8	68.063	53.456	25.918
$\frac{5}{16}$	234.9	184.5	69.098	54.269	26.114
$\frac{3}{8}$	238.5	187.3	70.141	55.088	26.311
$\frac{7}{16}$	242.0	190.1	71.191	55.914	26.507
$\frac{1}{2}$	245.6	193.0	72.250	56.745	26.704
$\frac{9}{16}$	249.3	195.7	73.316	57.583	26.900
$\frac{5}{8}$	252.9	198.7	74.391	58.426	27.096
$\frac{11}{16}$	256.6	201.6	75.473	59.276	27.293
$\frac{3}{4}$	260.3	204.4	76.563	60.132	27.489
$\frac{13}{16}$	264.1	207.4	77.660	60.994	27.685
$\frac{7}{8}$	267.9	210.3	78.766	61.862	27.882
$\frac{15}{16}$	271.6	213.3	79.879	62.737	28.078
9	275.4	216.3	81.000	63.617	28.274
$\frac{1}{16}$	279.3	219.3	82.129	64.505	28.471
$\frac{1}{8}$	283.2	222.4	83.266	65.397	28.667
$\frac{3}{16}$	287.0	225.4	84.410	66.296	28.863
$\frac{1}{4}$	290.9	228.5	85.563	67.201	29.060
$\frac{5}{16}$	294.9	231.5	86.723	68.112	29.256
$\frac{3}{8}$	298.9	234.7	87.891	69.029	29.452
$\frac{7}{16}$	302.8	237.9	89.066	69.953	29.649
$\frac{1}{2}$	306.8	241.0	90.250	70.882	29.845
$\frac{9}{16}$	310.9	244.2	91.441	71.818	30.041
$\frac{5}{8}$	315.0	247.4	92.641	72.760	30.238
$\frac{11}{16}$	319.1	250.6	93.848	73.708	30.434
$\frac{3}{4}$	323.2	253.9	95.063	74.662	30.631
$\frac{13}{16}$	327.4	257.1	96.285	75.622	30.827
$\frac{7}{8}$	331.6	260.4	97.516	76.589	31.023
$\frac{15}{16}$	335.8	263.7	98.754	77.561	31.022

PART III.

HYDRAULICS, DATA ON WATER, SEWERS, ETC., EXCAVATION TABLES, TIN AND SHEET METAL WORK, SIZES, WEIGHTS, ETC., OF SHEET METAL.

Hydraulics.

TABLE SHOWING CAPACITIES OF CENTRIFUGAL PUMPS, ALSO USEFUL DATA REGARDING SAME.

Size Pump (Diameter Discharge Pipe).	Size Pipe for Suction, Inches.	Economical Capacity, Gallons per Minute.	Horse-Power Required for each Foot Elevation.	Diameter and Face of Pulley in Inches.
1½	2	70	.058	6×6
1¾	2	90	.075	7×8
2	3	120	.10	8×8
2½	3	180	.15	8×8
3	4	260	.22	8×8
4	5	470	.30	10×10
5	6	735	.45	12×12
6	8	1050	.59	15×12
8	10	2000	1.00	20×12
10	12	3000	1.52	24×12
12	15	4200	2.00	30×14
15	18	7000	3.50	40×15
15	18	7000	3.50	30×15
18	20	10000	4.50	40×16
18	20	10000	4.50	30×16
20	22	12000	5.40	36×20
22	24	13000	5.50	48×20
24	24	15000	6.50	48×36

CAPACITY OF SAND AND DREDGING CENTRIFUGAL PUMPS.

No. Pump (Diameter Discharge Opening)	Diameter Suction.	Cubic Yards Material per Hour, 10 to 20 Per Cent of Solids.			Horsepower Required for each 10 Feet Elevation.	Will Pass Solids: Diameter, Inches.	Diameter and Face of Pulley.
		10 Per Cent.	15 Per Cent.	20 Per Cent.			
4	4	14	21	28	4	2	12×12
6	6	30	45	60	8	4½	20×12
8	8	60	90	120	15	6	24×14
10	10	90	135	180	25	8	30×15
12	12	125	190	250	30	10	36×20
15	15	210	315	420	50	10	42×24
18	18	300	450	600	70	10	48×30

REVOLUTION TABLE

Speeds at which Standard Pumps should Run to Raise Water to Different Heights.

No.	5 Ft.	10 Ft.	15 Ft.	25 Ft.	35 Ft.	50 Ft.	70 Ft.	100 Ft.
1½	428	604	739	955	1131	1351	1599	1911
1¾	348	491	601	777	920	1099	1301	1554
2	302	426	522	674	798	953	1128	1348
2½	302	426	522	674	798	953	1128	1348
3	302	426	522	674	798	953	1128	1348
4	285	402	493	637	754	901	1066	1274
5	256	362	443	572	678	810	958	1145
6	214	302	368	478	566	675	800	955
8	183	259	317	409	485	579	685	819
10	168	238	291	376	445	532	629	752
12	133	188	230	298	352	421	498	595
15	105	148	181	234	277	331	391	468
15	151	213	261	337	399	477	564	674
18	105	148	181	234	277	331	391	468
18	151	213	261	337	399	477	564	674
20	142	202	245	317	376	450	532	635
24	95	134	163	212	252	300	355	424

If water is to be forced through long pipes or through many elbows, speed must be increased to correspond.

Weir-dam Measurement for Flow of Water in Streams.—Cut a notch in a board deep enough to pass all the water and about two-thirds the width of the stream,

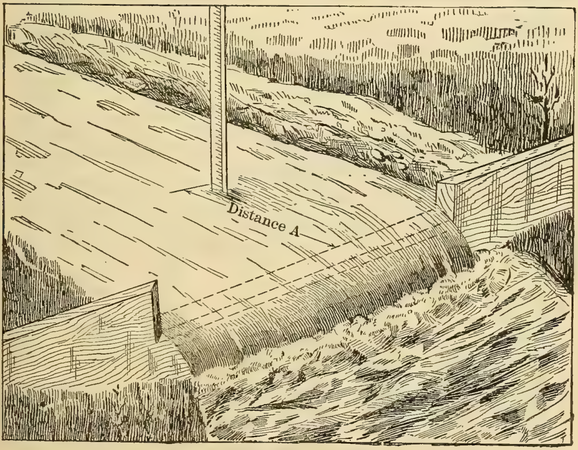


Fig. 63.

as shown by Fig. 63. Bevel the edges of the notch, then secure it in the position shown in the above view. Drive a stake

in the bottom of the stream about 4 or 5 feet from the board (shown as distance *A* in the view). The top of the stake must be exactly level with the bottom of the notch in the board. After the water has come to an even flow and reached its greatest depth, a careful measurement can be made of the depth of the water over the top of the stake. This measurement gives the true depth of water passing over notch. On the downward side, the water must have a drop of 10 to 15 inches after leaving the board to enable you to get the true flow.

The nature of the channel above the board should be such that the water will not rush over the board, but should be wide and deep enough to allow it to flow over quietly.

The Weir-dam table given below shows the number of cubic feet of water passing per minute over the notch for each inch in breadth. The figures in the first vertical column are the inches depth of water over the weir. The figures on first horizontal line show fractional parts of inches depth. The table shows cubic feet that will pass per minute per inch of width of notch in board.

Example.—Suppose the notch in the board is 20 inches wide and the water is $5\frac{1}{2}$ inches above top of stake. In the table

TABLE FOR WEIR-DAM MEASUREMENT,

Giving cubic feet of water per minute that will flow over a weir 1 inch wide and up to 25 inches deep.

Inch.		$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$
1	.40	.47	.55	.65	.74	.83	.93	1.03
2	1.14	1.24	1.36	1.47	1.59	1.71	1.83	1.96
3	2.09	2.23	2.36	2.50	2.63	2.78	2.92	3.07
4	3.22	3.37	3.52	3.68	3.83	3.99	4.16	4.32
5	4.50	4.67	4.84	5.01	5.18	5.36	5.54	5.72
6	5.90	6.09	6.28	6.47	6.65	6.85	7.05	7.25
7	7.44	7.64	7.84	8.05	8.25	8.45	8.66	8.86
8	9.10	9.31	9.52	9.74	9.96	10.18	10.40	10.62
9	10.86	11.08	11.31	11.54	11.77	12.00	12.23	12.47
10	12.71	12.95	13.19	13.43	13.67	13.93	14.16	14.42
11	14.67	14.92	15.18	15.43	15.67	15.96	16.20	16.46
12	16.73	16.99	17.26	17.52	17.78	18.05	18.32	18.58
13	18.87	19.14	19.42	19.69	19.97	20.24	20.52	20.80
14	21.09	21.37	21.65	21.94	22.22	22.51	22.79	23.08
15	23.38	23.67	23.97	24.26	24.56	24.86	25.16	25.46
16	25.76	26.06	26.36	26.66	26.97	27.27	27.58	27.89
17	28.20	28.51	28.82	29.14	29.45	29.76	30.08	30.39
18	30.70	31.02	31.34	31.66	31.98	32.31	32.63	32.96
19	33.29	33.61	33.94	34.27	34.60	34.94	35.27	35.60
20	35.94	36.27	36.60	36.94	37.28	37.62	37.96	38.31
21	38.65	39.00	39.34	39.69	40.04	40.39	40.73	41.09
22	41.43	41.78	42.13	42.49	42.84	43.20	43.56	43.92
23	44.28	44.64	45.00	45.38	45.71	46.08	46.43	46.81
24	47.18	47.55	47.91	48.28	48.65	49.02	49.39	49.76

$5\frac{1}{2}$ inches show that 5.18 cubic feet flow over 1 inch of width. Multiply this by 20 (width of notch), and you will have 103.6, which represents the cubic feet of water passing over the weir, or amount in the stream. This multiplied by $7\frac{1}{2}$ will give the gallons.

A "miners' inch" of water is approximately equal to a supply of 12 United States gallons per minute.

Measurements of Large Streams.—Where measurement by weir is impracticable, the amount of water can be calculated by ascertaining the average velocity of the current and the cross-section of the stream.

Select a place in the stream where there is a moderate current, or smooth, even flow of water, and measure the depth of the water at from 6 to 12 points across the stream at equal

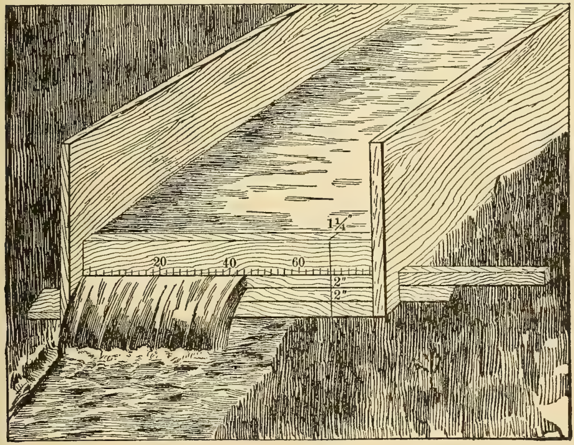


Fig. 64.

distances between. Add all the depths in feet together, and divide by the number of measurements made; this will be the average depth of the stream, which, multiplied by its width, will give its area or cross-section. Multiply this by the velocity of the stream in feet per minute, and the result will be the discharge in cubic feet per minute of the stream.

Miners' Inch Measurement.—The miners' inch is another method of measuring flow of water, and is commonly

used by the hydraulic companies in the western part of the United States.

The standard opening is 50 inches long by 2 inches wide in a 1¼-inch board, top of said opening being 6 inches from level of water in stream, as shown by Fig. 64. This is equivalent to 100 miners' inches, and will discharge 157 cubic feet per minute, commonly taken as 150 cubic feet.

If there is not 150 cubic feet in the stream, it will be necessary to close part of the longitudinal 2-inch opening, so that the water will stand 6 inches above the upper edge of the slot at all times. The length of the opening multiplied by two gives the number of miners' inches.

PRESSURE OF WATER.

Head in Feet.	Pressure in Pounds per Square Inch.	Head in Feet.	Pressure in Pounds per Square Inch.	Head in Feet.	Pressure in Pounds per Square Inch.	Head in Feet.	Pressure in Pounds per Square Inch
1	0.43	34	14.74	67	29.05	100	43.35
2	0.87	35	15.17	68	29.48	101	43.78
3	1.30	36	15.61	69	29.91	102	44.22
4	1.73	37	16.04	70	30.35	103	44.65
5	2.17	38	16.47	71	30.78	104	45.08
6	2.60	39	16.91	72	31.21	105	45.52
7	3.03	40	17.34	73	31.65	106	45.95
8	3.47	41	17.77	74	32.08	107	46.39
9	3.90	42	18.21	75	32.51	108	46.82
10	4.34	43	18.64	76	32.95	109	47.25
11	4.77	44	19.07	77	33.38	110	47.69
12	5.20	45	19.51	78	33.81	111	48.12
13	5.64	46	19.94	79	34.25	112	48.55
14	6.07	47	20.37	80	34.68	113	48 99
15	6.50	48	20.81	81	35.11	114	49.42
16	6.94	49	21.24	82	35.55	115	49.85
17	7.37	50	21.68	83	35.98	116	50.29
18	7.80	51	22.11	84	36.41	117	50.72
19	8.24	52	22.54	85	36.85	118	51.15
20	8.67	53	22.98	86	37.28	119	51.59
21	9.10	54	23.41	87	37.72	120	52.02
22	9.54	55	23.84	88	38.15	121	52.45
23	9.97	56	24.28	89	38.58	122	52.89
24	10.40	57	24.71	90	39.02	123	53.32
25	10.84	58	25.14	91	39.45	124	53.75
26	11.27	59	25.58	92	39.88	125	54.19
27	11.70	60	26.01	93	40.32	126	54.62
28	12.14	61	26.44	94	40.75	127	55.06
29	12.57	62	26.88	95	41.18	128	55.49
30	13.01	63	27.31	96	41.62	129	55.92
31	13.44	64	27.74	97	42.05	130	56.36
32	13.87	65	28.18	98	42.48	131	56.79
33	14.31	66	28.61	99	42.92	132	57.22

PRESSURE OF WATER—(*Continued*).

Head in Feet.	Pressure in Pounds per Sq. Inch.	Head in Feet.	Pressure in Pounds per Sq. Inch.	Head in Feet.	Pressure in Pounds per Sq. Inch.	Head in Feet.	Pressure in Pounds per Sq. Inch.
133	57.66	175	75.86	217	94.06	259	112.27
134	58.09	176	76.30	218	94.50	260	112.71
135	58.52	177	76.73	219	94.93	261	113.14
136	58.96	178	77.16	220	95.37	262	113.57
137	59.39	179	77.60	221	95.80	263	114.01
138	59.82	180	78.03	222	96.23	264	114.44
139	60.26	181	78.46	223	96.67	265	114.87
140	60.69	182	78.90	224	97.10	266	115.31
141	61.12	183	79.33	225	97.53	267	115.74
142	61.56	184	79.77	226	97.97	268	116.17
143	62.00	185	80.20	227	98.40	269	116.61
144	62.43	186	80.63	228	98.83	270	117.04
145	62.86	187	81.07	229	99.27	271	117.47
146	63.29	188	81.50	230	99.70	272	117.91
147	63.73	189	81.93	231	100.13	273	118.34
148	64.16	190	82.37	232	100.56	274	118.77
149	64.59	191	82.80	233	101.00	275	119.21
150	65.03	192	83.23	234	101.43	276	119.64
151	65.46	193	83.67	235	101.86	277	120.07
152	65.89	194	84.10	236	102.30	278	120.51
153	66.33	195	84.53	237	102.73	279	120.94
154	66.76	196	84.97	238	103.16	280	121.38
155	67.19	197	85.40	239	103.60	281	121.81
156	67.63	198	85.83	240	104.03	282	122.24
157	68.06	199	86.27	241	104.46	283	122.68
158	68.49	200	86.70	242	104.90	284	123.11
159	68.93	201	87.13	243	105.33	285	123.54
160	69.36	202	87.56	244	105.76	286	123.98
161	69.79	203	88.00	245	106.20	287	124.41
162	70.23	204	88.43	246	106.63	288	124.84
163	70.66	205	88.85	247	107.06	289	125.28
164	71.10	206	89.30	248	107.50	290	125.71
165	71.53	207	89.73	249	107.93	291	126.14
166	71.96	208	90.15	250	108.37	292	126.58
167	72.40	209	90.60	251	108.80	293	127.01
168	72.83	210	91.03	252	109.23	294	127.44
169	73.26	211	91.46	253	109.67	295	127.88
170	73.70	212	91.90	254	110.10	296	128.31
171	74.13	213	92.33	255	110.53	297	128.74
172	74.56	214	92.76	256	110.97	298	129.18
173	75.00	215	93.20	257	111.40	299	129.61
174	75.43	216	93.63	258	111.83	300	130.05

VELOCITY OF WATER.

Table giving velocity of water in feet per second, and the cubic feet of water per minute, to develop one horse-power at 80 per cent duty under heads from 1 to 108 feet.

Head	Velocity.	Cubic Feet.	Head	Velocity.	Cubic Feet.	Head	Velocity.	Cubic Feet.
1	8.02	661.765	37	48.78	17.886	73	68.53	9.065
2	11.34	330.883	38	49.44	17.415	74	69.00	8.943
3	13.89	220.589	39	50.09	16.968	75	69.46	8.822
4	16.04	165.441	40	50.72	16.544	76	69.92	8.707
5	17.92	132.353	41	51.35	16.141	77	70.38	8.594
6	19.65	110.294	42	54.98	15.756	78	70.84	8.484
7	21.22	94.538	43	52.59	15.390	79	71.29	8.377
8	22.68	82.720	44	53.20	15.040	80	71.74	8.272
9	24.06	73.529	45	53.80	14.706	81	72.19	8.170
10	25.36	66.177	46	54.40	14.368	82	72.63	8.070
11	26.60	60.160	47	54.99	14.080	83	73.07	7.973
12	27.78	55.147	48	55.57	13.787	84	73.51	7.878
13	28.92	50.905	49	56.14	13.505	85	73.95	7.785
14	30.01	47.269	50	56.71	13.236	86	74.38	7.695
15	31.06	44.118	51	57.27	12.976	87	74.81	7.606
16	32.08	41.360	52	57.84	12.726	88	75.24	7.520
17	33.07	38.927	53	58.39	12.486	89	75.67	7.436
18	34.03	36.765	54	58.93	12.255	90	76.09	7.353
19	34.96	34.830	55	59.48	12.032	91	76.51	7.272
20	35.87	33.088	56	60.01	11.817	92	76.93	7.193
21	36.75	31.513	57	60.56	11.610	93	77.35	7.116
22	37.61	30.080	58	61.08	11.410	94	77.76	7.040
23	38.46	28.772	59	61.61	11.216	95	78.18	6.966
24	39.29	27.574	60	62.12	11.029	96	78.59	6.893
25	40.10	26.471	61	62.71	10.849	97	79.00	6.822
26	40.89	25.453	62	63.15	10.674	98	79.40	6.753
27	41.67	24.510	63	63.66	10.504	99	79.81	6.685
28	42.44	23.634	64	64.16	10.340	100	80.22	6.618
29	43.19	22.819	65	64.66	10.181	101	80.61	6.552
30	43.93	22.059	66	65.16	10.027	102	81.01	6.487
31	44.65	21.347	67	65.65	9.877	103	81.40	6.425
32	45.37	20.680	68	66.14	9.732	104	81.80	6.363
33	46.07	20.053	69	66.62	9.591	105	82.19	6.303
34	46.77	19.464	70	67.11	9.454	106	82.58	6.243
35	47.45	18.908	71	67.58	9.321	107	82.97	6.185
36	48.12	18.382	72	68.06	9.191	108	83.35	6.127

RESISTANCE IN CIRCULAR BENDS OF WATER PIPE.

Head required to overcome resistance in circular bends of 90°, exclusive friction. For a bend of less than 90°, divide the resistance given in this table by 90, and multiply by the number of degrees of bend.

Velocity in Feet per Second.	Ratio of $\frac{\text{Radius of bend at center of pipe}}{\text{Diameter of pipe}}$								
	1	1.25	1.5	1.75	2	2.5	3	3.5	4
	Loss of Head in Feet.								
1	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002
2	0.018	0.013	0.010	0.009	0.009	0.008	0.008	0.008	0.008
3	0.041	0.029	0.024	0.021	0.020	0.019	0.019	0.018	0.018
4	0.073	0.051	0.042	0.038	0.036	0.034	0.033	0.033	0.033
5	0.114	0.080	0.066	0.060	0.056	0.053	0.052	0.052	0.051
6	0.164	0.115	0.095	0.086	0.081	0.077	0.075	0.074	0.074
7	0.224	0.156	0.130	0.117	0.111	0.105	0.102	0.101	0.101
8	0.292	0.204	0.169	0.153	0.144	0.137	0.134	0.132	0.131
9	0.370	0.259	0.214	0.194	0.183	0.173	0.169	0.167	0.166
10	0.456	0.319	0.265	0.239	0.226	0.214	0.209	0.206	0.205
11	0.552	0.386	0.320	0.289	0.273	0.258	0.253	0.250	0.248
12	0.657	0.460	0.381	0.344	0.325	0.308	0.301	0.297	0.296
13	0.771	0.540	0.447	0.404	0.381	0.361	0.353	0.349	0.347
14	0.895	0.626	0.519	0.469	0.442	0.419	0.409	0.405	0.402
15	1.027	0.719	0.596	0.538	0.508	0.481	0.470	0.465	0.462
16	1.169	0.818	0.678	0.612	0.578	0.547	0.535	0.529	0.526
17	1.319	0.923	0.765	0.691	0.652	0.617	0.603	0.597	0.593
18	1.480	1.035	0.858	0.775	0.731	0.692	0.677	0.670	0.665
19	1.648	1.153	0.956	0.863	0.815	0.771	0.754	0.746	0.741
20	1.826	1.278	1.059	0.957	0.903	0.855	0.835	0.826	0.821
21	2.013	1.408	1.674	1.055	0.996	0.942	0.921	0.911	0.906
22	2.209	1.546	1.281	1.157	1.093	1.034	1.011	1.000	0.994
23	2.415	1.690	1.400	1.265	1.194	1.130	1.105	1.093	1.086
24	2.629	1.840	1.525	1.377	1.300	1.231	1.203	1.190	1.284
25	2.853	1.996	1.654	1.495	1.411	1.335	1.305	1.291	1.183

HORSE-POWER AND FLOW OF WATER THROUGH NOZZLES OR JETS.

Diameter of Jet.
p — Effective horse-power.
q — Cubic feet of water per minute.

Effective Head in Feet.	Hydrost. Press. in Lbs. per Sq. In.	H. P. per Sq. Inch of Jet.		1/4″	3/8″	1/2″	5/8″	3/4″	1″	1 1/4″	1 1/2″	1 3/4″	2″	2 1/4″	2 1/2″	3″	3 1/2″	4″	4 1/2″
10	4.33	0.16	p	0.01	0.02	0.03	0.05	0.07	0.12	0.19	0.28	0.38	0.50	0.63	0.78	1.12	1.53	2.00	2.53
			q	0.52	1.17	2.07	3.24	4.67	8.30	12.	18.	25.	33.	42.	51.	74.	101.	132.	168.
15	6.50	0.29	p	0.01	0.03	0.06	0.09	0.13	0.23	0.36	0.52	0.70	0.92	1.16	1.43	2.06	2.81	3.66	4.64
			q	0.63	1.43	2.54	3.97	5.72	10.	15.	22.	31.	40.	51.	63.	91.	124.	162.	205.
20	8.66	0.45	p	0.02	0.05	0.09	0.14	0.20	0.44	0.55	0.79	1.08	1.41	1.79	2.21	3.17	4.33	5.64	7.14
			q	0.73	1.65	2.93	4.58	6.60	11.	18.	26.	35.	46.	59.	73.	105.	143.	187.	237.
25	10.	0.63	p	0.03	0.07	0.12	0.19	0.28	0.49	0.77	1.11	1.51	1.97	2.50	3.08	4.44	6.04	7.89	9.98
			q	0.82	1.85	3.26	5.13	7.38	13.	20.	29.	40.	52.	66.	82.	118.	160.	209.	265.
30	13.	0.83	p	0.04	0.09	0.16	0.25	0.36	0.65	1.01	1.46	1.99	2.59	3.28	4.05	5.71	7.94	10.	13.
			q	0.90	2.02	3.59	5.61	8.08	14.	22.	32.	44.	57.	72.	89.	129.	176.	229.	291.
35	15.	1.04	p	0.05	0.11	0.20	0.32	0.46	0.82	1.28	1.84	2.50	3.27	4.14	5.11	7.35	10.	13.	16.
			q	0.97	2.18	3.88	6.06	8.73	15.	24.	34.	47.	62.	78.	97.	139.	190.	248.	314.
40	17.	1.27	p	0.06	0.14	0.25	0.39	0.56	1.00	1.56	2.25	3.05	3.99	5.05	6.25	8.98	12.	15.	20.
			q	1.04	2.33	4.15	6.48	9.34	16.	25.	37.	50.	66.	84.	103.	149.	203.	265.	336.
45	19.	1.52	p	0.07	0.17	0.30	0.47	0.67	1.19	1.86	2.68	3.65	4.76	6.03	7.44	10.	14.	19.	24.
			q	1.10	2.47	4.40	6.88	9.90	17.	27.	39.	54.	70.	89.	110.	158.	215.	281.	356.
50	21.	1.78	p	0.09	0.20	0.35	0.54	0.78	1.39	2.18	3.14	4.27	5.58	7.06	8.72	12.	17.	22.	28.
			q	1.16	2.61	4.64	7.25	10.	18.	28.	41.	56.	73.	93.	115.	167.	227.	296.	375.
60	26.	2.33	p	0.11	0.26	0.46	0.72	1.03	1.83	2.86	4.12	5.61	7.33	9.28	11.	16.	22.	29.	37.
			q	1.27	2.86	5.08	7.94	11.	20.	31.	45.	62.	81.	102.	127.	182.	249.	325.	411.
70	30.	2.94	p	0.14	0.32	0.58	0.90	1.30	2.31	3.61	5.20	7.07	9.24	11.	14.	20.	28.	36.	46.
			q	1.37	3.09	5.49	8.58	12.	21.	34.	49.	67.	87.	111.	137.	197.	268.	351.	444.
80	34.	3.59	p	0.18	0.40	0.71	1.10	1.59	2.82	4.41	6.35	8.64	11.	14.	17.	25.	34.	45.	57.
			q	1.47	3.30	5.87	9.17	13.	23.	36.	52.	71.	93.	118.	146.	211.	287.	375.	475.
90	39.	4.29	p	0.21	0.47	0.84	1.32	1.89	3.37	5.26	7.58	10.	13.	17.	21.	30.	41.	53.	68.
			q	1.55	3.50	6.22	9.72	14.	24.	38.	56.	76.	99.	126.	155.	224.	304.	398.	504.
100	43.	5.02	p	0.25	0.55	0.99	1.54	2.22	3.94	6.16	8.87	12.	15.	19.	24.	35.	48.	63.	79.
			q	1.64	3.69	6.56	10.	14.	26.	41.	59.	80.	104.	132.	164.	236.	321.	419.	531.

HORSE-POWER AND FLOW OF WATER THROUGH NOZZLES OR JETS—*Continued.*

Effective Head in Feet.	Hydrost. Press. in Lbs. per Sq. In.	H. P. per Sq. Inch of Jet.		Diameter of Jet. p — Effective horse-power. q — Cubic feet of water per minute. $\frac{1}{4}''$	$\frac{3}{8}''$	$\frac{1}{2}''$	$\frac{5}{8}''$	$\frac{3}{4}''$	1″	$1\frac{1}{4}''$	$1\frac{1}{2}''$	$1\frac{3}{4}''$	2″	$2\frac{1}{4}''$	$2\frac{1}{2}''$	3″	$3\frac{1}{2}''$	4″	$4\frac{1}{2}''$
110	47.	5.79	p	0.28	0.64	1.14	1.78	2.56	4.55	7.11	10.	13.	18.	23.	28.	40.	55.	72.	92.
			q	1.72	3.87	6.88	10.	15.	27.	43.	61.	84.	110.	139.	172.	247.	337.	440.	557.
120	52.	6.60	p	0.32	0.93	1.30	2.03	2.92	5.19	8.10	11.	15.	20.	26.	32.	46.	63.	82.	104.
			q	1.80	4.04	7.18	11.	16.	28.	44.	64.	88.	114.	145.	179.	258.	352.	459.	582.
130	56.	7.44	p	0.37	0.82	1.46	2.28	3.29	5.85	9.14	13.	17.	23.	29.	36.	52.	71.	93.	118.
			q	1.87	4.21	7.48	11.	16.	29.	46.	67.	91.	119.	151.	187.	269.	366.	478.	605.
140	60.	8.34	p	0.41	0.92	1.64	2.56	3.68	6.55	10.	14.	20.	26.	33.	40.	58.	80.	104.	132.
			q	1.94	4.37	7.76	12.	17.	31.	48.	69.	95.	124.	157.	194.	279.	380.	496.	628.
150	65.	9.23	p	0.45	1.02	1.81	2.83	4.08	7.25	11.	16.	22.	28.	36.	45.	65.	88.	115.	146.
			q	2.01	4.52	8.04	12.	18.	32.	50.	72.	98.	128.	162.	200.	289.	393.	514.	650.
160	69.	10.16	p	0.50	1.12	2.00	3.12	4.49	7.98	12.	17.	24.	31.	40.	49.	71.	97.	127.	161.
			q	2.07	4.67	8.30	12.	18.	33.	51.	74.	101.	132.	168.	207.	298.	406.	531.	672.
170	73.	11.13	p	0.55	1.23	2.19	3.42	4.92	8.74	13.	19.	26.	34.	44.	54.	78.	107.	139.	177.
			q	2.14	4.81	8.55	13.	19.	34.	53.	76.	104.	136.	173.	213.	307.	419.	547.	692.
180	78.	12.13	p	0.60	1.34	2.38	3.72	5.36	9.53	14.	21.	29.	38.	48.	59.	85.	116.	152.	192.
			q	2.20	4.95	8.80	13.	19.	35.	55.	79.	107.	140.	178.	220.	316.	431.	563.	712.
190	82.	13.15	p	0.65	1.45	2.58	4.04	5.81	10.	16.	23.	31.	41.	52.	64.	92.	126.	165.	209.
			q	2.26	5.09	9.04	14.	20.	36.	56.	81.	110.	144.	183.	226.	325.	443.	578.	732.
200	86.	14.20	p	0.70	1.57	2.79	4.36	6.28	11.	17.	25.	34.	44.	56.	69.	100.	136.	178.	225.
			q	2.32	5.22	9.28	14.	20.	37.	57.	83.	113.	148.	187.	231.	334.	454.	593.	751.
210	91.	15.28	p	0.75	1.69	3.00	4.69	6.75	12.	18.	27.	36.	48.	60.	75.	108.	147.	192.	243.
			q	2.38	5.35	9.51	14.	21.	38.	59.	85.	116.	152.	192.	237.	342.	465.	608.	770.
220	95.	16.39	p	0.80	1.81	3.22	5.03	7.24	12.	20.	28.	39.	51.	65.	80.	115.	157.	205.	260.
			q	2.43	5.47	9.73	15.	21.	38.	60.	87.	119.	155.	197.	243.	350.	476.	622.	788.
230	99.	17.52	p	0.86	1.94	3.44	5.37	7.74	13.	21.	31.	42.	55.	69.	85.	123.	168.	220.	278.
			q	2.49	5.60	9.95	15.	22.	39.	62.	89.	121.	159.	201.	248.	358.	487.	636.	805.
240	140.	18.67	p	0.92	2.06	3.67	5.73	8.25	14.	22.	33.	44.	58.	74.	91.	131.	179.	234.	296.
			q	2.54	5.72	10.	15.	22.	40.	63.	91.	124.	162.	205.	254.	365.	498.	650.	823.

HORSE-POWER AND FLOW OF WATER THROUGH NOZZLES OR JETS—*Continued.*

Diameter of Jet.
p — Effective horse-power.
q — Cubic feet of water per minute.

Effective Head in Feet.	Hydrost. Press. in Lbs. per Sq. In.	H. P. per Sq. Inch of Jet.		1/4″	3/8″	1/2″	5/8″	3/4″	1″	1 1/4″	1 1/2″	1 3/4″	2″	2 1/4″	2 1/2″	3″	3 1/2″	4″	4 1/2″
250	108.	19.85	p	0.97	2.19	3.90	6.09	8.77	15.	24.	35.	47.	62.	78.	97.	140.	191.	249.	315.
			q	2.59	5.84	10.	16.	23.	41.	64.	93.	127.	165.	210.	259.	373.	508.	663.	840.
260	112.	21.05	p	1.03	2.33	4.13	6.46	9.30	16.	25.	37.	50.	66.	83.	103.	148.	202.	264.	334.
			q	2.64	5.95	10.	16.	23.	42.	66.	95.	129.	169.	214.	264.	380.	518.	677.	856.
270	117.	22.28	p	1.09	2.46	4.38	6.84	9.84	17.	27.	39.	53.	70.	88.	109.	157.	214.	280.	354.
			q	2.69	6.06	10.	16.	24.	43.	67.	97.	132.	172.	218.	269.	388.	528.	689.	873.
280	121.	23.53	p	1.16	2.60	4.62	7.22	10.	18.	28.	41.	56.	73.	93.	115.	166.	226.	295.	374.
			q	2.74	6.17	10.	17.	24.	43.	68.	98.	134.	175.	222.	274.	395.	537.	702.	889.
290	125.	24.80	p	1.22	2.74	4.87	7.61	10.	19.	30.	43.	59.	77.	98.	121.	175.	238.	311.	394.
			q	2.80	6.28	11.	17.	25.	44.	69.	100.	136.	178.	226.	279.	402.	547.	715.	904.
300	130.	26.10	p	1.28	2.88	5.12	8.01	11.	20.	32.	46.	62.	81.	103.	128.	184.	251.	327.	415.
			q	2.84	6.39	11.	17.	25.	45.	71.	102.	139.	181.	230.	284.	409.	556.	727.	920.
310	134.	27.41	p	1.35	3.03	5.38	8.41	12.	21.	33.	48.	65.	86.	109.	134.	193.	263.	344.	435.
			q	2.89	6.50	11.	18.	25.	46.	72.	103.	141.	184.	233.	288.	415.	566.	739.	935.
320	138.	28.75	p	1.41	3.18	5.64	8.82	12.	22.	35.	50.	69.	90.	114.	141.	203.	276.	361.	457.
			q	2.93	6.60	11.	18.	26.	46.	73.	105.	143.	187.	237.	293.	422.	575.	751.	950.
330	143.	30.04	p	1.48	3.32	5.91	9.24	13.	23.	36.	53.	72.	94.	119.	147.	212.	289.	378.	478.
			q	2.97	6.70	11.	18.	26.	47.	74.	107.	145.	190.	241.	297.	429.	583.	762.	965.
340	147.	31.49	p	1.55	3.48	6.18	9.66	13.	24.	38.	55.	75.	98.	125.	154.	222.	302.	395.	500.
			q	3.02	6.81	12.	18.	27.	48.	75.	108.	148.	193.	244.	302.	435.	592.	774.	979.
350	151.	32.89	p	1.61	3.63	6.46	10.	14.	25.	40.	58.	79.	103.	130.	161.	232.	316.	413.	523.
			q	3.07	6.90	12.	19.	27.	49.	76.	110.	150.	196.	248.	306.	441.	601.	785.	994.
360	156.	34.30	p	1.68	3.79	6.74	10.	15.	26.	42.	60.	82.	107.	136.	168.	242.	330.	431.	545.
			q	3.11	7.00	12.	19.	28.	49.	77.	112.	152.	199.	252.	311.	448.	609.	796.	1008.
370	160.	35.74	p	1.75	3.95	7.02	10.	15.	28.	43.	63.	85.	112.	142.	175.	252.	343.	449.	568.
			q	3.15	7.10	12.	19.	28.	50.	78.	113.	154.	201.	255.	315.	454.	618.	807.	1022.
380	164.	37.20	p	1.83	4.11	7.30	11.	16.	29.	45.	65.	89.	116.	147.	182.	262.	357.	467.	591.
			q	3.20	7.20	12.	19.	28.	51.	79.	115.	156.	204.	258.	319.	460.	626.	818.	1035.

HORSE-POWER AND FLOW OF WATER THROUGH NOZZLES OR JETS—*Continued.*

Diameter of Jet.
p — Effective horse-power.
q — Cubic feet of water per minute.

Effective Head in Feet.	Hydrost. Press. in Lbs. per Sq. In.	H. P. per Sq. Inch of Jet.		1/4″	3/8″	1/2″	5/8″	3/4″	1″	1 1/4″	1 1/2″	1 3/4″	2″	2 1/4″	2 1/2″	3″	3 1/2″	4″	4 1/2″
390	169.	38.68	p	1.90	4.27	7.60	11.	17.	30.	47.	68.	93.	121.	153.	189.	273.	372.	486.	615.
			q	3.25	7.29	12.	20.	29.	51.	80.	116.	158.	207.	262.	323.	466.	634.	829.	1049.
400	173.	40.18	p	1.97	4.44	7.89	12.	17.	31.	49.	71.	96.	126.	159.	197.	284.	386.	504.	638.
			q	3.28	7.38	13.	20.	29.	52.	82.	118.	160.	209.	265.	328.	472.	642.	839.	1062.
410	177.	41.69	p	2.05	4.61	8.19	12.	18.	32.	51.	73.	100.	131.	165.	204.	294.	402.	523.	663.
			q	3.32	7.47	13.	20.	29.	53.	83.	119.	162.	212.	269.	332.	478.	650.	850.	1076.
420	182.	43.23	p	2.12	4.78	8.49	13.	19.	33.	53.	76.	103.	135.	171.	212.	305.	415.	543.	687.
			q	3.36	7.56	13.	21.	30.	53.	84.	121.	164.	215.	272.	336.	484.	658.	860.	1089.
430	186.	44.78	p	2.20	4.95	8.79	13.	19.	35.	54.	79.	107.	140.	178.	219.	316.	430.	562.	712.
			q	3.40	7.65	13.	21.	30.	54.	85.	122.	166.	217.	275.	340.	489.	666.	870.	1101.
440	190.	46.35	p	2.28	5.12	9.10	14.	20.	36.	56.	81.	111.	145.	184.	227.	327.	445.	582.	737.
			q	3.44	7.74	13.	21.	30.	55.	86.	123.	168.	220.	278.	344.	495.	674.	880.	1114.
450	195.	47.94	p	2.35	5.30	9.41	14.	21.	37.	58.	84.	115.	150.	190.	235.	338.	461.	602.	762.
			q	3.48	7.83	13.	21.	31.	55.	86.	125.	170.	222.	281.	347.	501.	681.	890.	1127.
460	199.	49.55	p	2.43	5.47	9.73	15.	21.	38.	60.	87.	119.	155.	197.	243.	350.	476.	622.	788.
			q	3.52	7.92	14.	21.	31.	56.	87.	126.	172.	225.	284.	351.	506.	689.	900.	1139.
470	203.	51.17	p	2.51	5.65	10.	15.	22.	40.	62.	90.	123.	160.	203.	251.	361.	492.	643.	813.
			q	3.55	8.00	14.	22.	32.	56.	88.	128.	174.	227.	288.	355.	512.	696.	910.	1152.
480	208.	52.81	p	2.59	5.83	10.	16.	23.	41.	64.	93.	127.	165.	210.	259.	373.	508.	663.	839.
			q	3.59	8.08	14.	22.	32.	57.	89.	129.	176.	229.	291.	359.	517.	704.	919.	1164.
490	212.	54.47	p	2.67	6.02	10.	16.	24.	42.	66.	96.	131.	171.	216.	267.	385.	524.	684.	866.
			q	3.63	8.17	14.	22.	32.	58.	90.	130.	177.	232.	294.	363.	522.	711.	929.	1176.
500	216.	56.15	p	2.76	6.20	11.	17.	24.	44.	68.	99.	135.	176.	223.	275.	396.	540.	705.	893.
			q	3.67	8.25	14.	22.	33.	58.	91.	132.	179.	234.	297.	366.	528.	718.	938.	1188.
550	238.	64.78	p	3.18	7.16	12.	19.	28.	50.	79.	114.	155.	203.	257.	317.	457.	623.	814.	1030.
			q	3.85	8.66	15.	24.	34.	61.	96.	138.	188.	246.	311.	384.	553.	753.	984.	1246.
600	260.	73.81	p	3.62	8.15	14.	22.	32.	58.	90.	130.	177.	231.	293.	362.	521.	710.	927.	1173.
			q	4.02	9.04	16.	25.	36.	64.	100.	144.	196.	257.	235.	401.	578.	787.	1028.	1301.

HORSE-POWER AND FLOW OF WATER THROUGH NOZZLES OR JETS—*Continued.*

Diameter of Jet.
p — Effective horse-power.
q — Cubic feet of water per minute.

Effective Head in Feet.	Hydrost. Press. in Lbs. per Sq. In.	H.P. per Sq. Inch of Jet.	¼″	⅜″	½″	⅝″	¾″	1″	1¼″	1½″	1¾″	2″	2¼″	2½″	3″	3½″	4″	4½″
650	281.	83.23	p 4.09	9.19	16.	25.	36.	65.	102.	147.	200.	261.	330.	408.	588.	800.	1045.	1323.
			q 4.18	9.41	16.	26.	37.	66.	104.	150.	204.	267.	338.	418.	602.	819.	1070.	1354.
700	303.	93.01	p 4.56	10.	18.	28.	41.	73.	114.	164.	223.	292.	369.	456.	657.	894.	1168.	1479.
			q 4.34	9.76	17.	27.	39.	69.	108.	156.	212.	277.	351.	433.	624.	850.	1110.	1405.
750	325.	103.15	p 5.06	11.	20.	31.	45.	81.	126.	182.	248.	324.	410.	506.	729.	992.	1296.	1640.
			q 4.49	10.	17.	28.	40.	71.	112.	161.	220.	287.	363.	449.	646.	880.	1149.	1455.
800	346.	113.64	p 5.58	12.	22.	34.	50.	89.	139.	200.	273.	357.	451.	557.	803.	1093.	1428.	1807.
			q 4.64	10.	18.	29.	41.	74.	115.	167.	227.	296.	375.	463.	668.	909.	1187.	1503.
850	368.	124.46	p 6.11	13.	24.	38.	54.	97.	152.	219.	299.	391.	494.	610.	879.	1197.	1563.	1979.
			q 4.78	10.	19.	29.	43.	76.	119.	172.	234.	306.	387.	478.	688.	937.	1224.	1549.
900	390.	135.60	p 6.66	14.	26.	41.	59.	106.	166.	239.	326.	426.	539.	665.	958.	1304.	1703.	2156.
			q 4.92	11.	19.	30.	44.	78.	123.	177.	241.	314.	398.	492.	708.	964.	1259.	1594.
950	411.	147.05	p 7.22	16.	28.	45.	64.	115.	180.	259.	353.	461.	584.	721.	1039.	1414.	1847.	2338.
			q 5.05	11.	20.	31.	45.	80.	126.	181.	247.	323.	409.	505.	727.	990.	1294.	1637.
1000	433.	158.82	p 7.80	17.	32.	48.	70.	124.	194.	280.	382.	498.	631.	779.	1122.	1527.	1995.	2525.
			q 5.19	11.	20.	32.	46.	82.	129.	186.	254.	331.	420.	518.	746.	1016.	1327.	1680.
1100	476.	183.22	p 8.99	20.	35.	56.	80.	143.	224.	323.	440.	575.	728.	899.	1295.	1762.	2302.	2913.
			q 5.44	12.	21.	34.	48.	87.	136.	195.	266.	348.	440.	543.	783.	1066.	1392.	1762.
1200	520.	208.77	p10.	23.	40.	64.	92.	163.	256.	368.	502.	655.	830.	1024.	1475.	2008.	2623.	3320.
			q 5.68	12.	22.	35.	51.	90.	142.	204.	278.	363.	460.	568.	818.	1113.	1454.	1840.
1300	563.	235.40	p11.	26.	46.	72.	104.	184.	288.	415.	566.	739.	935.	1155.	1663.	2264.	2958.	3743.
			q 5.91	13.	23.	36.	53.	94.	147.	212.	289.	378.	479.	591.	851.	1159.	1513.	1915.
1400	606.	263.08	p12.	29.	51.	80.	116.	206.	322.	464.	632.	826.	1046.	1291.	1859.	2531.	3305.	4184.
			q 6.14	13.	24.	38.	55.	98.	153.	220.	300.	392.	497.	613.	883.	1202.	1570.	1988.
1500	650.	291.76	p14.	32.	57.	89.	128.	229.	358.	515.	701.	916.	1160.	1432.	2062.	2807.	3666.	4640.
			q 6.35	14.	25.	39.	57.	101.	158.	228.	311.	406.	514.	635.	914.	1245.	1626.	2058.

FIRE STREAMS.

Pressures required at nozzle and at pump, with quantity and pressure of water necessary to throw water various distances through different-sized nozzles—using 2½-inch rubber hose and smooth nozzles.—G. A. Ellis, C.E.

Size of Nozzles.	1 Inch.				1⅛ Inch.			
Pressure at nozzle.	40	60	80	100	40	60	80	100
* Pressure at pump or hydrant with 100 ft. 2½-inch rubber hose.	48	73	97	121	54	81	108	135
Gallons per minute.	155	189	219	245	196	240	277	310
Horizontal distance thrown.	109	142	168	186	113	148	175	193
Vertical dist. thrown. . .	79	108	131	148	81	112	137	157

Size of Nozzles.	1¼ Inch.				1⅜ Inch.			
Pressure at nozzle.	40	60	80	100	40	60	80	100
* Pressure at pump or hydrant with 100 ft. 2½-inch rubber hose.	61	92	123	154	71	107	144	180
Gallons per minute.	242	297	342	383	293	358	413	462
Horizontal distance thrown.	118	156	186	207	124	166	200	224
Vertical dist. thrown. . .	82	115	142	164	85	118	146	169

* For greater lengths of 2½ hose the increased friction can readily be obtained by noting the differences between the above given "pressure at nozzle" and "pressure at pump or hydrant with 100 *feet* of hose." For instance, if it requires at hydrant or pump 8 lbs. more pressure than it does at nozzle to overcome the friction when pumping through 100 feet of 2½-inch hose (using 1-inch nozzle, with 40 lbs. pressure at said nozzle), then it requires 16 lbs. pressure to overcome the friction in forcing through 200 feet of same size hose.

Compressibility of Water (Kent). — Water is very slightly compressible; its compressibility is from .000040 to .000051 for one atmosphere, decreasing with increase of temperature. For each foot of pressure distilled water will be diminished in volume .0000015 to .0000013. Water is so incompressible that even at a depth of a mile a cubic foot of water will weigh only about half a pound more than at the surface.

TABLE SHOWING FLOW OF WATER PER SECOND THROUGH CLEAN IRON PIPES.

Fall in Feet per 100 Feet of Pipe.	Diameters.								
	1 In. Cu. Ft.	2 In. Cu. Ft.	3 In. Cu. Ft.	4 In. Cu. Ft.	6 In. Cu. Ft.	8 In. Cu. Ft.	10 In. Cu. Ft.	11 In. Cu. Ft.	12 In. Cu. Ft.
.10	......	......	......	......	......	......	......	......	1.265
.12	......	......	......	......	......	......	.878	1.120	1.402
.14	......	......	......	......	......	......	.960	1.221	1.489
.16	......	......	......	......	......	.573	1.047	1.320	1.634
.18	......	......	......	......	......	.611	1.110	1.394	1.728
.20	......	......	......	......	.298	.639	1.194	1.490	1.846
.22	......	......	......	......	.314	.659	1.265	1.580	1.940
.24	......	......	......	......	.330	.703	1.325	1.653	2.026
.26	......	......	......	.1235	.346	.737	1.377	1.722	2.117
.28	......	......	......	.1298	.359	.768	1.423	1.788	2.207
.30	......	......	.0630	.1335	.377	.808	1.470	1.854	2.297
.35	......	......	.0692	.1465	.395	.876	1.587	1.996	2.466
.40	......	.02584	.0749	.1562	.444	.931	1.683	2.136	2.662
.50	......	.02924	.0839	.1771	.496	1.045	1.865	2.397	3.020
.60	......	.03274	.0915	.1923	.548	1.575	2.059	2.636	3.310
.70	......	.03492	.0992	.2146	.589	1.262	2.222	2.858	3.601
.80	.00567	.03776	.1060	.2339	.631	1.344	2.383	3.062	3.856
.90	.00617	.04081	.1119	.2460	.672	1.424	2.514	3.232	4.072
1.00	.00677	.04321	.1190	.2582	.721	1.496	2.662	3.419	4.305
1.20	.00781	.04843	.1313	.2893	.784	1.644	2.932	3.760	4.728
1.40	.00841	.05150	.1413	.3036	.858	1.782	3.210	4.016	5.094
1.60	.00886	.05456	.1507	.3237	.922	1.916	3.450	4.390	5.482
1.80	.00961	.05740	.1590	.3412	.975	2.033	3.679	4.679	5.839
2.00	.00990	.06111	.1717	.3607	1.022	2.155	3.856	5.251	6.160
3.00	.01245	.07399	.2081	.4503	1.263	2.667	4.762	6.086	7.630
4.00	.01492	.08734	.2469	.5331	1.484	3.145	5.563	7.022	8.860
5.00	.01666	.1095	.2785	.5954	1.665	3.513	6.704	8.244	9.967
6.00	.01857	.1200	.3049	.6390	1.929	3.847	......	......	......
7.00	.01988	.1288	.3331	.6967	1.976	4.196	......	......	......
8.00	.02141	.1375	.3559	.7506	2.144	......	......	......	......
9.00	.02283	.1442	.3816	.7960	2.274	......	......	......	......
10.00	.02424	.1523	.4043	.9464	2.399	......	......	......	......
12.00	.02676	.1634	.4440	.9270	......	......	......	......	......
14.00	.02890	.1748	.4977	1.0060	......	......	......	......	......
15.98	.03081	.1855	.5131	1.0810	......	......	......	......	......
18.00	.03276	.1955	.5436	......	......	......	......	......	......
20.00	.03458	.2047	.5832	......	......	......	......	......	......
25.00	.03897	.2276	.6523	......	......	......	......	......	......
30.00	.04316	.2483	......	......	......	......	......	......	......
40.00	.04987	.2833	......	......	......	......	......	......	......
50.00	.05648	......	......	......	......	......	......	......	......
60.00	.06320	......	......	......	......	......	......	......	......
70.00	.06943	......	......	......	......	......	......	......	......

To find the velocity in feet per second necessary to carry a given quantity of water in a pipe of given diameter, divide the quantity in cubic feet per second by the area of the pipe in square feet; the quotient will give the velocity.

TABLE SHOWING FLOW OF WATER PER SECOND THROUGH CLEAN IRON PIPES.

Fall in Feet per 100 Feet of Pipe.	Diameter.											
	14 In. Cu. Ft.	15 In. Cu. Ft.	16 In. Cu. Ft.	18 In. Cu. Ft.	20 In. Cu. Ft.	22 In. Cu. Ft.	24 In. Cu. Ft.	26 In. Cu. Ft.	30 In. Cu. Ft.	36 In. Cu. Ft.	40 In. Cu. Ft.	48 In. Cu. Ft.
.02	....	....	....	....	....	....	....	....	....	10.29	13.88	22.98
.03	....	....	....	....	....	....	....	....	7.78	12.70	17.00	27.39
.04	....	....	....	....	....	....	....	....	8.99	14.56	19.68	32.93
.05	....	....	....	....	....	....	....	7.48	10.24	16.35	22.08	37.00
.06	....	....	....	....	3.61	4.61	6.10	7.61	10.97	18.02	24.43	40.21
.07	....	....	2.25	3.10	4.07	5.25	6.64	8.27	11.90	19.76	26.27	43.67
.08	1.71	2.05	2.43	3.27	4.35	5.62	7.13	8.70	12.84	20.85	28.14	46.81
.09	1.83	2.19	2.59	3.49	4.68	6.01	7.56	9.36	13.48	22.30	29.80	49.06
.10	1.91	2.30	2.72	3.66	4.92	6.32	7.95	9.81	14.21	23.47	31.46	52.15
.11	2.02	2.43	2.88	3.88	5.15	6.62	8.34	10.44	15.05	24.91	33.25	54.95
.12	2.11	2.54	3.02	4.06	5.40	6.94	8.75	10.87	15.81	26.12	34.68	57.36
.13	2.18	2.65	3.18	4.23	5.62	7.24	9.14	11.41	16.47	27.20	36.21	60.07
.14	2.27	2.75	3.28	4.40	5.82	7.51	9.47	11.80	17.18	28.24	37.57	62.02
.15	2.35	2.84	3.39	4.61	6.05	7.78	9.80	12.26	17.94	29.19	39.18	64.47
.16	2.44	2.94	3.49	4.75	6.27	8.03	10.13	12.70	18.58	30.29	40.54	66.53
.17	2.54	2.98	3.62	4.90	6.48	8.36	10.57	13.13	19.21	31.42	41.88	68.50
.18	2.59	3.11	3.69	5.03	6.65	8.55	10.77	13.46	19.66	32.48	43.07	70.62
.19	2.67	3.21	3.81	5.17	6.92	8.85	11.10	13.84	20.32	33.40	44.28	72.75
.20	2.72	3.29	3.92	5.30	7.05	9.07	11.43	14.23	20.79	34.49	45.20	74.44
.22	2.88	3.47	4.12	5.63	7.42	9.55	12.05	14.98	21.80	36.15	48.12	78.29
.24	3.02	3.63	4.32	5.87	7.79	10.01	12.61	15.69	22.83	37.74	50.48	81.68
.26	3.15	3.79	4.51	6.18	8.14	10.48	13.23	16.42	23.93	39.40	52.67	85.20
.28	3.29	3.95	4.68	6.38	8.48	10.91	13.79	17.07	24.86	40.86	55.04	88.46
.30	3.42	4.11	4.87	6.64	8.77	11.29	14.25	17.75	25.87	42.28	56.33	91.73
.35	3.62	4.46	5.31	7.17	9.49	12.25	15.50	19.25	27.96	45.95	61.09	100.40
.40	3.99	4.78	5.67	7.65	10.16	13.12	16.62	20.62	29.84	48.83	65.41	105.89
.50	4.46	5.37	6.39	8.66	11.43	14.78	18.71	23.13	33.55	54.89	73.09	119.34
.60	4.91	5.91	7.02	9.54	12.59	16.20	20.42	25.30	36.79	59.95	80.32	130.88
.70	5.37	6.45	7.66	10.33	13.66	17.53	22.05	27.12	39.66	65.17	86.70	148.09
.80	5.77	6.90	8.16	11.09	14.66	18.78	23.61	29.20	42.39	69.80	92.58	153.49
.90	6.11	7.31	8.64	11.71	15.54	19.93	25.07	31.00	45.23	74.33	98.00	.....
1.00	6.44	7.70	9.10	12.37	16.47	21.06	26.42	32.73	47.71	78.46	103.99	.....
1.20	7.00	8.39	9.95	13.65	17.99	23.07	29.03	36.18	52.91	82.84	.....	.....
1.40	7.60	9.15	10.87	14.75	19.49	24.68	31.49	39.31	57.65	....	.....	.....
1.60	8.17	9.81	11.63	15.84	21.03	26.97	33.90	42.35	....	....	.....	.....
1.80	8.93	10.47	12.43	16.90	22.45	29.70	36.18	44.10	....	....	.....	.....
2.00	9.26	11.09	13.14	17.85	23.56	31.15	38.45	....	....	....	.....	.....
3.00	11.39	13.66	16.17	21.86	28.86	....	....	....	....	....	.....	.....
4.00	13.22	15.84	18.77	....	....	....	....	....	....	....	.....	.....

To find the area of a required pipe, the quantity and velocity being given, divide the quantity in a stated time by the velocity in the same period; the quotient will be the required area, from which the diameter may readily be calculated.

LOSS OF HEAD BY FRICTION.

The following tables give the friction head in pipe 1 to 12 inches diameter, per 100 feet length, with velocities from 2 to 7 feet per second.

INSIDE DIAMETER OF PIPE IN INCHES.

Velocity in Feet per Sec.	1		2		3		4	
	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.
2.0	2.37	.65	1.185	2.62	.791	5.89	.593	10.4
2.2	2.80	.73	1.404	2.88	.936	6.48	.702	11.5
2.4	3.27	.79	1.639	3.14	1.093	7.07	.819	12.5
2.6	3.78	.86	1.891	3.40	1.26	7.65	.945	13.6
2.8	4.32	.92	2.16	3.66	1.44	8.24	1.08	14.6
3.0	4.89	.99	2.44	3.92	1.62	8.83	1.22	15.7
3.2	5.47	1.06	2.73	4.18	1.82	9.42	1.37	16.7
3.4	6.09	1.12	3.05	4.45	2.04	10.00	1.52	17.8
3.6	6.76	1.19	3.38	4.71	2.26	10.60	1.69	18.8
3.8	7.48	1.26	3.74	4.97	2.49	11.20	1.87	19.9
4.0	8.20	1.32	4.10	5.23	2.73	11.80	2.05	20.9
4.2	8.97	1.39	4.49	5.49	2.98	12.30	2.24	22.0
4.4	9.77	1.45	4.89	5.76	3.25	12.90	2.43	23.0
4.6	10.60	1.52	5.30	6.02	3.53	13.50	2.64	24.0
4.8	11.45	1.58	5.72	6.28	3.81	14.10	2.85	25.1
5.0	12.33	1.65	6.17	6.54	4.11	14.70	3.08	26.2
5.2	13.24	1.72	6.62	6.80	4.41	15.30	3.31	27.2
5.4	14.20	1.78	7.10	7.06	4.73	15.90	3.55	28.2
5.6	15.16	1.85	7.58	7.32	5.06	16.50	3.79	29.3
5.8	16.17	1.91	8.09	7.58	5.40	17.10	4.04	30.3
6.0	17.23	1.98	8.61	7.85	5.74	17.70	4.31	31.4
7.0	22.89	2.31	11.45	9.16	7.62	20.60	5.72	36.6

INSIDE DIAMETER OF PIPE IN INCHES.

Velocity in Feet per Sec.	5		6		7		8	
	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.
2.0	.474	16.3	.395	23.5	.338	32.0	.96	41.9
2.2	.561	18.0	.468	25.9	.401	35.3	.351	46.1
2.4	.650	19.6	.547	28.2	.468	38.5	.410	50.2
2.6	.757	21.3	.631	30.6	.540	41.7	.473	54.4
2.8	.864	22.9	.720	32.9	.617	44.9	.540	58.6
3.0	.978	24.5	.815	35.3	.698	48.1	.611	62.8
3.2	1.098	26.2	.915	37.7	.785	51.3	.686	67.0
3.4	1.22	27.8	1.021	40.0	.875	54.5	.765	71.2
3.6	1.35	29.4	1.131	42.4	.969	57.7	.848	75.4
3.8	1.49	31.0	1.25	44.7	1.070	60.9	.936	79.6
4.0	1.64	32.7	1.37	47.1	1.175	64.1	1.027	83.7
4.2	1.79	34.3	1.49	49.5	1.28	67.3	1.122	87.9
4.4	1.95	36.0	1.62	51.8	1.39	70.5	1.22	92.1
4.6	2.11	37.6	1.76	54.1	1.51	73.7	1.32	96.3
4.8	2.27	39.2	1.90	56.5	1.63	76.9	1.43	100.0
5.0	2.46	40.9	2.05	58.9	1.76	80.2	1.54	105.0
5.2	2.65	42.5	2.21	61.2	1.89	83.3	1.65	109.0
5.4	2.84	44.2	2.37	63.6	2.03	86.6	1.77	113.0
5.6	3.03	45.8	2.53	65.9	2.17	89.8	1.89	117.0
5.8	3.24	47.4	2.70	68.3	2.31	93.0	2.01	121.0
6.0	3.45	49.1	2.87	70.7	2.46	96.2	2.15	125.0
7.0	4.57	57.2	3.81	82.4	3.26	112.0	2.85	146.0

LOSS OF HEAD BY FRICTION—(*Continued*).

INSIDE DIAMETER OF PIPE IN INCHES.

Velocity in Feet per Sec.	9		10		11		12	
	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.
2.0	.264	53	.237	65.4	.216	79.2	.198	94
2.2	.312	58.3	.281	72	.255	87.1	.234	103
2.4	.365	63.6	.327	78.5	.297	95.0	.273	113
2.6	.420	68.9	.378	85.1	.344	103	.315	122
2.8	.480	74.2	.432	91.6	.392	111	.360	132
3.0	.544	79.5	.488	98.2	.444	119	.407	141
3.2	.609	84.8	.549	105	.499	127	.457	151
3.4	.680	90.1	.612	111	.557	134	.510	160
3.6	.755	95.4	.679	118	.617	142	.566	169
3.8	.831	101	.749	124	.680	150	.624	179
4.0	.913	106	.822	131	.747	158	.685	188
4.2	.998	111	.897	137	.816	166	.749	198
4.4	1.086	116	.977	144	.888	174	.815	207
4.6	1.177	122	1.059	150	.963	182	.883	217
4.8	1.27	127	1.145	157	1.040	190	.954	226
5.0	1.37	132	1.23	163	1.122	198	1.028	235
5.2	1.47	138	1.32	170	1.20	206	1.104	245
5.4	1.57	143	1.41	177	1.28	214	1.183	254
5.6	1.68	148	1.51	183	1.37	222	1.26	264
5.8	1.80	154	1.61	190	1.46	229	1.34	273
6.0	1.92	159	1.71	196	1.56	237	1.43	283
7.0	2.52	185	2.28	229	2.07	277	1.91	330

The following tables give the friction head in pipe 13 to 36 inches' diameter, per 100 feet length with velocities of water from 2 to 7 feet per second.

INSIDE DIAMETER OF PIPE IN INCHES.

Velocity in Feet per Sec.	13		14		15		16	
	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.
2.0	.183	110	.169	128	.158	147	.147	167
2.2	.216	121	.200	141	.187	162	.175	184
2.4	.252	133	.234	154	.218	176	.205	201
2.6	.290	144	.270	167	.252	191	.236	218
2.8	.332	156	.308	179	.288	206	.270	234
3.0	.375	166	.349	192	.325	221	.306	251
3.2	.422	177	.392	205	.366	235	.343	268
3.4	.471	188	.438	218	.408	250	.383	284
3.6	.522	199	.485	231	.452	265	.425	301
3.8	.576	210	.535	243	.499	280	.468	318
4.0	.632	221	.587	256	.548	294	.513	335
4.2	.691	232	.641	269	.598	309	.561	352
4.4	.751	243	.698	282	.651	324	.611	368
4.6	.815	254	.757	295	.707	339	.662	385
4.8	.881	265	.818	308	.763	353	.715	402
5.0	.949	276	.881	321	.822	368	.770	419
5.2	1.020	287	.947	333	.883	383	.828	435
5.4	1.092	298	1.014	346	.947	397	.888	452
5.6	1.167	309	1.083	359	1.011	412	.949	469
5.8	1.245	321	1.155	372	1.078	427	1.011	486
6.0	1.325	332	1.229	385	1.148	442	1.076	502
7.0	1.75	387	1.630	449	1.520	515	1.430	586

LOSS OF HEAD BY FRICTION—(*Continued*).

INSIDE DIAMETER OF PIPE IN INCHES.

Velocity in Feet per Sec.	18		20		22		24	
	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.
2.0	.132	212	.119	262	.108	316	.098	377
2.2	.156	233	.140	288	.127	348	.116	414
2.4	.182	254	.164	314	.149	380	.136	452
2.6	.210	275	.189	340	.171	412	.157	490
2.8	.240	297	.216	366	.195	443	.180	528
3.0	.271	318	.245	393	.222	475	.204	565
3.2	.305	339	.275	419	.249	507	.229	603
3.4	.339	360	.306	445	.278	538	.255	641
3.6	.377	382	.339	471	.308	570	.283	678
3.8	.416	403	.374	497	.340	601	.312	716
4.0	.456	424	.410	523	.373	633	.342	754
4.2	.499	445	.449	550	.408	665	.374	791
4.4	.542	466	.488	576	.444	697	.407	829
4.6	.588	488	.529	602	.482	728	.441	867
4.8	.636	509	.572	628	.521	760	.476	905
5.0	.685	530	.617	654	.561	792	.513	942
5.2	.736	551	.662	680	.602	823	.552	980
5.4	.788	572	.710	707	.645	855	.591	1018
5.6	.843	594	.758	733	.690	887	.632	1055
5.8	.899	615	.809	759	.735	918	.674	1093
6.0	.957	636	.861	785	.782	950	.717	1131
7.0	1.270	742	1.143	916	1.040	1109	.953	1319

INSIDE DIAMETER OF PIPE IN INCHES.

Velocity in Feet per Sec.	26		28		30		36	
	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.	Loss of Head in Feet.	Cubic Feet per Min.
2.0	.091	442	.084	513	.079	589	.066	848
2.2	.108	486	.099	564	.093	648	.078	933
2.4	.126	531	.116	616	.109	707	.091	1018
2.6	.145	575	.134	667	.126	766	.104	1100
2.8	.165	619	.153	718	.144	824	.119	1188
3.0	.188	663	.174	770	.163	883	.135	1273
3.2	.211	708	.195	821	.182	942	.152	1357
3.4	.235	752	.218	872	.204	1001	.169	1442
3.6	.261	796	.242	923	.226	1060	.188	1527
3.8	.288	840	.267	974	.249	1119	.207	1612
4.0	.315	885	.293	1026	.273	1178	.228	1697
4.2	.345	929	.320	1077	.299	1237	.249	1782
4.4	.375	973	.348	1129	.325	1296	.271	1866
4.6	.407	1017	.378	1180	.353	1355	.294	1951
4.8	.440	1062	.409	1231	.381	1414	.318	2036
5.0	.474	1106	.440	1283	.411	1472	.342	2121
5.2	.510	1150	.473	1334	.441	1531	.368	2206
5.4	.546	1194	.507	1385	.473	1590	.394	2291
5.6	.583	1239	.542	1437	.506	1649	.421	2376
5.8	.622	1283	.578	1488	.540	1708	.450	2460
6.0	.662	1327	.615	1539	.574	1767	.479	2545
7.0	.879	1548	.817	1796	.762	2061	.636	2968

Example.—Have 200 feet head and 600 feet of 11-inch pipe, carrying 119 cubic feet of water per minute. To find effective head. In right-hand column under 11-inch pipe, find 119 cubic feet; opposite this will be found the coefficient of friction for this amount of water, which is 444. Multiply this by the number of hundred feet of pipe, which is 6, and you will have 2.66 feet, which is the loss of head. Therefore the effective head is 200 − 2.66 = 197.34.

CONTENTS IN CUBIC FEET, U. S. GALLONS, AND WEIGHT OF WATER PER FOOT LENGTH FOR PIPE OF VARIOUS DIAMETERS, ALSO AREA IN SQUARE FEET AND INCHES, AND CIRCUMFERENCE IN INCHES.*

Diameter of Pipe in Inches.	Area in Sq. Feet or Contents in Cubic Feet per Foot of Length.	Contents in U. S. Gallons per Foot Length.	Weight of Water in One-foot Length, in Pounds.	Area in Sq. Inches.	Circumference in Inches.
1	.0055	.0408	.34	.78	3.14
2	.0218	.1632	1.36	3.14	6.28
3	.0491	.3672	3.06	7.06	9.42
4	.0873	.6528	5.44	12.56	12.56
5	.1364	1.020	8.51	19.63	15.70
6	.1963	1.469	12.25	28.27	18.85
7	.2673	1.999	16.68	38.48	21.99
8	.3491	2.611	21.79	50.26	25.13
9	.4418	3.305	27.57	63.61	28.27
10	.5454	4.08	34.04	78.54	31.41
11	.66	4.937	41.19	95.03	34.55
12	.7854	5.875	49.02	113.10	37.69
13	.9218	6.895	57.54	132.73	40.84
14	1.069	7.997	66.73	153.94	43.98
15	1.227	9.180	76.60	176.71	47.12
16	1.396	10.44	87.16	201.06	50.26
18	1.768	13.22	110.31	254.47	56.54
20	2.182	16.32	136.19	314.16	62.83
22	2.640	19.75	164.79	380.13	69.11
24	3.142	23.50	196.11	452.39	75.39
26	3.687	27.58	230.16	530.93	81.68
28	4.276	31.99	266.93	615.75	87.96
30	4.909	36.72	306.42	706.86	94.24
32	5.585	41.78	348.64	804.25	100.53
34	6.305	47.16	393.59	907.92	106.81
36	7.069	52.88	441.25	1017.9	113.09
38	7.876	58.92	491.64	1134.1	119.38
40	8.727	65.28	544.76	1256.6	125.66
42	9.621	71.97	600.59	1385.4	131.94
44	10.559	78.99	659.16	1520.5	138.23
46	11.541	86.33	720.44	1661.9	144.51
48	12.566	94.00	784.45	1809.6	150.79
50	13.635	102.00	851.18	1963.5	157.08
52	14.748	110.32	920.64	2123.7	163.36
54	15.90	118.97	992.82	2290.2	169.64
60	19.63	146.88	1225.71	2827.4	188.49
66	23.76	177.72	1483.11	3421.2	207.34
72	28.27	211.51	1765.02	4071.5	226.19

* Also see table on page 247.

AMOUNT OF WATER AND PRESSURE IN PNEUMATIC TANKS.

Pneumatic tanks are used to elevate water to various heights by means of compressed air in the tank obtained by forcing water in the tank when it is full of air, the tank and connections being air-tight.

The pressure in the tank increases as the water is forced in.

The amount of water in the tank at various pressures is as follows:

At 5 pounds pressure the tank is about one-fourth full of water.
At 10 pounds pressure the tank is about two-fifths full of water.
At 15 pounds pressure the tank is about one-half full of water.
At 20 pounds pressure the tank is about three-fifths full of water.
At 23 pounds pressure the tank is about two-thirds full of water.
At 30 pounds pressure the tank is about seven-tenths full of water.
At 45 pounds pressure the tank is about three-fourths full of water.
At 60 pounds pressure the tank is about four-fifths full of water.

Thus by means of a pressure gauge the amount of water in the tank can be ascertained at any time.

The height to which the various pressures will elevate water is as follows:

5 pounds pressure will elevate water about 11 feet.
10 pounds pressure will elevate water about 23 feet.
15 pounds pressure will elevate water about 34 feet.
20 pounds pressure will elevate water about 46 feet.
25 pounds pressure will elevate water about 57 feet.
30 pounds pressure will elevate water about 69 feet.
45 pounds pressure will elevate water about 103 feet.
60 pounds pressure will elevate water about 138 feet.

To drain a pneumatic tank a valve below the tank should be opened. If a valve above the tank be opened it will only lower the water in the tank to the height obtained by the pressure of water to the height of the valve. Thus a valve 11 feet above the tank will only draw water down to 5 pounds pressure, or will still leave the tank one-quarter full of water. This is due to the hydrostatic pressure (or pressure of the weight of the water) at the height of 11 feet, which equals about 5 pounds pressure in the tank.

The supply from a pneumatic tank should always be taken from the bottom, so as to draw off the water and not the air which is compressed in the top of the tank.

The tank of a pneumatic system should be entirely emptied once in a while to fill the tank with air; if there should be a leak and the air escape it lowers the amount of air in the tank and also the pressure.

EQUATION OF PIPES.

It is frequently desired to know what number of pipes of a given size are equal in carrying capacity to one pipe of a larger size. At the same velocity of flow the volume delivered by two pipes of different sizes is proportional to the squares of their diameters; thus, one 4-inch pipe will deliver the same volume as four 2-inch pipes. With the same head, however, the velocity is less in the smaller pipe, and the volume delivered varies about as the square root of the fifth power (i.e., as the 2.5 power). The following table has been calculated on this basis. The figures opposite the intersection of any two sizes represent the number of the smaller-sized pipes required to equal one of the larger. Thus, one 4-inch pipe is equal to 5.7 2-inch pipes.

Diameter, Inches.	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	24
2	5.7	1														
3	15.6	2.8	1													
4	32	5.7	2.1	1												
5	55.9	9.9	3.6	1.7	1											
6	88.2	15.6	5.7	2.8	1.6	1										
7	130	22.9	8.3	4.1	2.3	1.5	1									
8	181	32	11.7	5.7	3.2	2.1	1.4	1								
9	243	43	15.6	7.6	4.3	2.8	1.9	1.3	1							
10	316	55.9	20.3	9.9	5.7	3.6	2.4	1.7	1.3	1						
11	401	70.9	25.7	12.5	7.2	4.6	3.1	2.2	1.7	1.3						
12	499	88.2	32	15.6	8.9	5.7	3.8	2.8	2.1	1.6	1					
13	609	108	39.1	19	10.9	7.1	4.7	3.4	2.5	1.9	1.2					
14	733	130	47	22.9	13.1	8.3	5.7	4.1	3.0	2.3	1.5	1				
15	787	154	55.9	27.2	15.6	9.9	6.7	4.8	3.6	2.8	1.7	1.2				
16	......	181	65.7	32	18.3	11.7	7.9	5.7	4.2	3.2	2.1	1.4	1			
17	......	211	76.4	37.2	21.3	13.5	9.2	6.6	4.9	3.8	2.4	1.6	1.2			
18	......	243	88.2	43	24.6	15.6	10.6	7.6	5.7	4.3	2.8	1.9	1.3	1		
19	......	278	101	49.1	28.1	17.8	12.1	8.7	6.5	5	3.2	2.1	1.5	1.1		
20	......	316	115	55.9	32	20.3	13.8	9.9	7.4	5.7	3.6	2.4	1.7	1.3	1	
22	......	401	146	70.9	40.6	25.7	17.5	12.5	9.3	7.2	4.6	3.1	2.2	1.7	1.3	
24	......	499	181	88.2	50.5	32	21.8	15.6	11.6	8.9	5.7	3.8	2.8	2.1	1.6	1
26	......	609	221	108	61.7	39.1	26.6	19	14.2	10.9	7.1	4.7	3.4	2.5	1.9	1.2
28	......	733	266	130	74.2	47	32	22.9	17.1	13.1	8.3	5.7	4.1	3	2.3	1.5
30	......	787	316	154	88.2	55.9	38	27.2	20.3	15.6	9.9	6.7	4.8	3.6	2.8	1.7
36	......	......	499	243	130	88.2	60	43	32	24.6	15.6	10.6	7.6	5.7	4.3	2.8
42	......	......	733	357	205	130	88.2	63.2	47	36.2	19	15.6	11.2	8.3	6.4	4.1
48	......	......	......	499	286	181	123	88.2	62.7	50.5	32	21.8	15.6	11.6	8.9	5.7
54	......	......	......	670	383	243	165	118	88.2	67.8	43	29.2	20.9	15.6	12	7.6
60	......	......	......	787	499	316	215	154	115	88.2	55.9	38	27.2	20.3	15.6	9.9

WEIGHT OF WATER PER CUBIC FOOT AT DIFFERENT TEMPERATURES.

Temperature, Fahrenheit.	Weight, Pounds per Cubic Foot.	Temperature, Fahrenheit.	Weight, Pounds per Cubic Foot.	Temperature, Fahrenheit.	Weight, Pounds per Cubic Foot.	Temperature, Fahrenheit.	Weight, Pounds per Cubic Foot.	Temperature, Fahrenheit.	Weight, Pounds per Cubic Foot.
32°	62.42	140°	61.37	240°	59.10	350°	55.52	460°	51.26
40	62.42	150	61.18	250	58.81	360	55.16	470	50.85
50	62.41	160	60.98	260	58.52	370	54.79	480	50.44
60	62.37	170	60.77	270	58.21	380	54.41	490	50.05
70	62.31	180	60.55	280	57.90	390	54.03	500	49.61
80	62.23	190	60.32	290	57.59	400	53.64	510	49.20
90	62.13	200	60.07	300	57.26	410	53.26	520	48.78
100	62.02	210	59.82	310	56.93	420	52.86	530	48.36
110	61.69	212	59.71	320	56.58	430	52.47	540	47.94
120	61.74	220	59.64	330	56.24	440	52.07	550	47.52
130	61.56	230	59.37	340	55.88	450	51.66	560	47.10

Data on Pumps.—DEPTH OF SUCTION.—Theoretically a perfect pump will lift water from a depth of nearly 34 feet, corresponding to a perfect vacuum (14.7 lbs. $\times 2.309 = 33.95$ feet); but since a perfect vacuum cannot be obtained, on account of valve leakage, air contained in the water, and the vapor of the water itself, the actual height is generally less than 30 feet. In pumping hot water, the water must flow into the pump by gravity. The following table shows the theoretical maximum depth of suction for different temperatures, leakage not considered:

Temperature, F.	Absolute Pressure of Vapor, Pounds per Sq. Inch.	Vacuum in Inches of Mercury.	Maximum Depth of Suction, Feet.	Temperature, F.	Absolute Pressure of Vapor, Pounds per Sq. Inch.	Vacuum in Inches of Mercury.	Maximum Depth of Suction, Feet.
101.4	1	27.88	31.6	183.0	8	13.63	15.5
126.2	2	25.85	29.3	188.4	9	11.59	13.2
144.7	3	23.81	27.0	193.2	10	9.55	10.9
153.3	4	21.77	24.7	197.6	11	7.51	8.5
162.5	5	19.74	22.4	201.9	12	5.48	6.2
170.3	6	17.70	20.1	205.8	13	3.44	3.9
177.0	7	15.66	17.8	209.6	14	1.40	1.6

A suction-lift pump is one that raises water only to the level of the pump spout.

A force-pump is one that raises water to the pump and also forces it to any reasonable altitude above the pump.

TABLE OF CAPACITY OF PUMPS.

The figures at the extreme left of the table are piston or plunger diameters; the line of figures across the top are piston or plunger strokes; the figures in the body of the table are the capacity or displacement in gallons, corresponding to a single stroke. To find the capacity for one revolution, multiply the capacity for a single stroke by two.

Diam. of Cylinder, Inches.	LENGTH OF STROKE IN INCHES.							
	2	3	4	5	6	7	12	13
1¼	.0106	.0159	.0212	.0266	.0319	.0372	.0638	.0691
1⅜	.0129	.0193	.0257	.0321	.0386	.045	.0771	.0835
1½	.0153	.0229	.0306	.0382	.0459	.0535	.0918	.0994
1¾	.0208	.0312	.0416	.0521	.0625	.0729	.1249	.1353
2	.0272	.0408	.0544	.068	.0816	.0952	.1632	.1768
2¼	.0344	.0516	.0688	.086	.1033	.1205	.2065	.2238
2½	.0425	.0638	.0850	.1063	.1275	.1488	.255	.2763
2¾	.0514	.0771	.1029	.1286	.1543	.18	.3086	.3343
3	.0612	.0918	.1224	.1530	.1836	.2142	.3672	.3978
3¼	.0718	.1077	.1437	.1796	.2154	.2514	.431	.4668
3½	.0833	.1249	.1666	.2082	.2499	.2915	.4997	.5414
3¾	.0957	.1435	.1913	.2392	.287	.3348	.574	.6214
4	.1088	.1632	.2176	.272	.3265	.3809	.653	.7074
4¼	.1229	.1843	.2457	.3071	.3684	.4300	.7371	.7986
4½	.1377	.2065	.2753	.3443	.413	.4818	.826	.8948
4¾	.1534	.2301	.3068	.3835	.4603	.537	.9205	.9972
5	.17	.2550	.34	.4250	.51	.5950	1.02	1.105
5¼	.1874	.2812	.3749	.4686	.5623	.6561	1.125	1.218
5½	.2057	.3086	.4114	.5143	.6171	.72	1.234	1.337
5¾	.2248	.3373	.4497	.5621	.6745	.787	1.349	1.461
6	.2448	.3672	.4896	.612	.7343	.8567	1.469	1.59
6¼	.2656	.3984	.5312	.6641	.7969	.9297	1.594	1.727
6½	.2872	.4309	.5745	.7182	.8618	1.005	1.724	1.867
6¾	.3099	.4648	.6197	.7747	.9296	1.085	1.859	2.014
7	.3332	.4999	.6665	.8331	.9997	1.166	1.999	2.166
7¾	.4084	.6126	.8168	1.021	1.225	1.429	2.45	2.654
8	.4352	.6529	.8704	1.089	1.306	1.523	2.611	2.829
9	.5508	.8263	1.102	1.377	1.652	1.928	3.305	3.580
10	.68	1.02	1.36	1.7	2.04	2.38	4.08	4.42
10½	.7497	1.125	1.499	1.874	2.249	2.624	4.498	4.873
11	.8228	1.234	1.646	2.057	2.468	2.88	4.937	5.348
12	.9792	1.469	1.958	2.448	2.938	3.427	5.875	6.365
13	1.149	1.723	2.297	2.872	3.445	4.022	6.894	7.467
14	1.332	1.998	2.665	3.331	3.997	4.664	7.994	8.661
15	1.53	2.295	3.06	3.825	4.59	5.354	9.18	9.943
16	1.74	2.61	3.48	4.35	5.22	6.09	10.44	11.31
18	2.203	3.305	4.406	5.508	6.61	7.711	13.22	14.32
20	2.720	4.08	5.440	6.8	8.16	9.52	16.32	17.68
22	3.291	4.936	6.582	8.228	9.874	11.52	19.75	21.39
24	3.916	5.875	7.833	9.792	11.75	13.71	23.5	25.46

TABLE OF CAPACITY OF PUMPS — *Continued.*

Diam. of Cylinder, Inches.	LENGTH OF STROKE IN INCHES.							
	16	18	20	24	25	33	36	38
1¼	.085	.0956	.1062	.1274	.1328	.1753	.1912	.2021
1⅜	.1029	.1156	.1286	.1543	.1607	.2121	.2314	.2442
1½	.1224	.1377	.1530	.1836	.1912	.2524	.2754	.2907
1¾	.1666	.1874	.2082	.2499	.2603	.3436	.3748	.3956
2	.2176	.2448	.2720	.3264	.340	.4489	.4897	.5169
2¼	.2754	.3098	.3442	.4131	.4303	.568	.6196	.6541
2½	.340	.3825	.425	.51	.5313	.7013	.765	.8075
2¾	.4114	.4628	.5143	.6171	.6429	.8486	.9257	.9771
3	.4896	.5508	.612	.7344	.765	1.01	1.102	1.163
3¼	.5746	.6464	.7183	.8619	.8978	1.185	1.293	1.365
3½	.6663	.7496	.833	.9995	1.041	1.374	1.499	1.583
3¾	.7653	.8610	.9561	1.148	1.196	1.579	1.722	1.818
4	.8706	.9795	1.088	1.306	1.36	1.796	1.959	2.068
4¼	.9828	1.106	1.229	1.474	1.536	2.027	2.211	2.333
4½	1.101	1.239	1.377	1.652	1.721	2.271	2.478	2.616
4¾	1.227	1.378	1.534	1.841	1.918	2.531	2.762	2.915
5	1.36	1.53	1.7	2.04	2.125	2.805	3.060	3.23
5¼	1.5	1.687	1.874	2.249	2.343	3.093	3.374	3.561
5½	1.646	1.851	2.057	2.468	2.571	3.394	3.703	3.908
5¾	1.799	2.023	2.248	2.698	2.811	3.71	4.047	4.272
6	1.958	2.203	2.448	2.938	3.06	4.038	4.406	4.65
6¼	2.125	2.39	2.656	3.188	3.32	4.383	4.781	5.047
6½	2.298	2.585	2.873	3.447	3.591	4.74	5.171	5.458
6¾	2.479	2.788	3.099	3.718	3.873	5.113	5.578	5.887
7	2.666	2.999	3.332	3.999	4.165	5.499	5.998	6.332
7¼	3.267	3.675	4.084	4.9	5.105	6.739	7.351	7.759
8	3.482	3.917	4.352	5.223	5.44	7.181	7.834	8.269
9	4.406	4.957	5.508	6.610	6.885	9.089	9.915	10.46
10	5.44	6.12	6.8	8.16	8.5	11.22	12.24	12.92
10½	5.998	6.747	7.497	8.996	9.37	12.37	13.49	14.24
11	6.582	7.405	8.228	9.873	10.28	13.58	14.81	15.63
12	7.834	8.813	9.792	11.75	12.24	16.16	17.63	18.6
13	9.192	10.34	11.49	13.78	14.36	18.96	20.69	21.83
14	10.66	11.99	13.32	15.98	16.66	21.99	23.99	25.32
15	12.23	13.77	15.29	18.36	19.12	25.24	27.54	29.07
16	13.92	15.66	17.40	20.88	21.76	28.72	31.33	33.07
18	17.62	19.82	22.03	26.44	27.54	36.35	39.66	41.86
20	21.76	24.48	27.2	32.64	34.	44.88	48.96	51.68
22	26.33	29.62	32.91	39.49	41.14	54.3	59.24	62.53
24	31.33	35.25	39.16	47.0	48.96	64.63	70.50	74.42

HEIGHTS IN FEET TO WHICH PUMPS WILL ELEVATE WATER.

Steam pressure, 50 pounds per square inch at the pump. No allowance made for friction in pipes, etc.

Diameter of Steam Cylinders.	Diameter of Water Cylinders.																
	2 Inch.	2½ Inch.	3 Inch.	3½ Inch.	4 Inch.	5 Inch.	6 Inch.	7 Inch.	8 Inch.	9 Inch.	10 Inch.	10½ Inch.	12 Inch.	14 Inch.	16 Inch.	18 Inch.	20 Inch.
3½	230	147	102	75	58	37	......	......	......	......	......	......	......	......	......	......	......
4	300	192	134	134	75	48	34	......	......	......	......	......	......	......	......	......	......
5	469	300	209	153	117	75	52	38	......	......	......	......	......	......	......	......	......
6	675	432	300	221	169	108	75	55	42	33	......	......	......	......	......	......	......
7	920	588	408	300	230	147	102	75	57	45	37	......	......	......	......	......	......
8	......	768	533	344	300	192	141	98	75	59	48	44	......	......	......	......	......
9	......	972	675	496	380	243	169	124	95	75	61	55	42	......	......	......	......
10	......	......	833	612	469	300	208	153	117	94	75	68	50	38	......	......	......
12	......	......	......	881	675	432	300	220	169	133	108	97	75	55	42	......	......
14	......	......	......	......	920	588	408	300	228	182	147	133	102	75	57	45	......
16	......	......	......	......	......	768	564	392	300	236	192	174	141	98	75	59	48
18	......	......	......	......	......	972	650	490	379	300	243	220	162	122	95	75	61
20	......	......	......	......	......	......	833	600	469	370	300	272	208	150	117	92	75
22	......	......	......	......	......	......	1008	741	567	448	364	329	252	185	142	112	91
24	......	......	......	......	......	......	......	882	675	533	432	392	300	220	169	133	108
26	......	......	......	......	......	......	......	1034	788	626	508	460	356	258	197	156	127
28	......	......	......	......	......	......	......	......	919	726	588	533	407	300	230	181	147
30	......	......	......	......	......	......	......	......	1054	834	676	612	468	345	263	208	169
32	......	......	......	......	......	......	......	......	......	948	798	697	533	391	300	237	192
34	......	......	......	......	......	......	......	......	......	1070	868	786	603	442	339	268	217
36	......	......	......	......	......	......	......	......	......	......	972	881	675	495	380	300	243

The maximum limit of piston speed depends upon the head pumped against.

Data Regarding Water.—Doubling the diameter of a pipe increases its capacity four times.

A gallon of water (United States standard) weighs 8.3311 pounds and contains 231 cubic inches.

A cubic foot of water contains 7½ gallons, 1728 cubic inches, and weighs 62½ pounds.

Cubic feet of water multiplied by 62.5 equals pounds avoirdupois; cubic inches of water multiplied by 0.03608 equals pounds avoirdupois.

Cubic feet multiplied by 7.48 equals United States gallons.

Cubic inches multiplied by 0.004329 equals United States gallons.

A column of water 1 inch square and 2.31 feet high weighs 1 pound.

A column of water 1 inch square and 1 foot high weighs 0.433 pound.

A column of water 33.947 feet high equals the pressure of the atmosphere at the sea-level.

Water is an almost universal solvent; consequently pure water does not occur in nature. Sea-water contains nearly every known substance in solution.

The latent heat of water is 79 thermal units. When water freezes it gives off its latent heat. The latent heat of steam is 536 thermal units. When steam condenses into water it gives off its latent heat.

Pure water consists of 2 parts hydrogen and 1 part oxygen. Chemical name, hydrogen oxide; chemical symbol, H_2O. Pure water is a colorless, odorless, tasteless, transparent liquid, and is practically incompressible. Water freezes at 32° Fahr. and boils at 212° Fahr. At its maximum density, 39.1° Fahr., it is the standard for specific gravities, and 1 cubic centimetre weighs 1 gram. Salt water boils at 224° Fahr.

$$1 \text{ U. S. gallon} = \begin{cases} \text{231 cubic inches.} \\ \text{0.13369 cubic foot.} \\ \text{8.3311 pounds of distilled water.} \\ \text{8.34 pounds in ordinary practice.} \end{cases}$$

1 cubic foot =	62.425 pounds at 39.1° Fahr., maximum density.
	62.418 pounds at 32° Fahr., freezing-point.
	62.355 pounds at 62° Fahr., standard temperature.
	59.64 pounds at 212° Fahr., boiling-point.
	57.5 pounds at ice.
	7.480 U. S. gallons.

1 pound = 27.7 cubic inches.
1 cubic inch = 0.03612-pound.

One ft. of water column at 39.1° F. = 62.425 lbs. on the square ft.
" " " " " " " = 0.4335 lb. " " " in.
" " " " " " " = 0.0295 atmospheric pressure.
" " " " " " " = 0.8826 in. mercury column at 32° F.
" " " " " " " = 773.3 ft. of air column at 32° F. and atmospheric pressure.
One lb. pressure on sq. ft. = 0.01602 ft. water column at 39.1° F.
" " " " " in. = 2.307 " " " " 39.1° F.
One atmospheric pressure = 29.92 in. mercury column = 33.9 ft. water column.
One inch of mercury column at 32° F. = 1.133 ft. water column.
One foot of air column at 32° F. and 1 atmospheric pressure = 0.001293 ft. water column.

Expansion of Water in Freezing. — That "cold contracts" is the law of physics, but as water cools it obeys this law only as far as 30° F. Then it slowly expands in cooling down to 32° F., its freezing point. Then its crystals suddenly dart out at an angle to each other and thus increasing in size about one-twelfth, it congeals and becomes ice. Ice, therefore, is lighter than water about one-twelfth, and consequently floats.

Pressure of Water at Various Depths. — To find the pressure of water at any depth, multiply the depth of the water in feet by 62.5.

The Pressure of Water in Tanks or Vessels. — The side of any tank or vessel containing water sustains a pressure equal to the area of the side in feet multiplied by one-half the depth in feet; that product multiplied by 62.5 will give the pressure in pounds on the side of the vessel.

The pressure on the bottom of the vessel equals the area of the bottom in feet multiplied by the depth of water in feet and that product multiplied by 62.5 equals the pressure in pounds.

Tensile Strain on Tanks. — The tension per square inch at any point in a tank is equal to the pressure per square inch at that point multiplied by the radius in inches.

Boiling Point of Water. — At sea level water boils at a temperature of 212° F. but at higher elevations it boils at a lower temperature; at the hospital of St. Bernard, in Switzerland, 8600 feet above sea level, water boils at 200°. In the Himalayas it has been found to boil at 180°.

Resistance of Friction. — The resistance of friction in the flow of water through pipes of uniform diameters is independent of the pressure and increases directly as the length and the square of the velocity of the flow, and inversely as the diameter of the pipe. With wooden pipes the friction is 1.75 times greater than in metallic.

To Determine Velocity. — To determine the velocity in feet per minute necessary to discharge a given volume of water in a given time, multiply the number of cubic feet of water by 144 and divide by the area of the pipe in inches.

To Determine the Area of Pipe Required. — To determine the area of a required pipe, the volume and velocity of water being given, multiply the number of cubic feet of water by 144 and divide the product by the velocity in feet per minute.

Useful Information Regarding Water. — The mean pressure of the atmosphere is usually estimated at 14.7 pounds per square inch, so that with a perfect vacuum it will sustain a column of mercury 29.9 inches, or a column of water 33.9 feet high.

To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by .434. Approximately, we say that every foot elevation is equal to

½ pound pressure per square inch; this allows for ordinary friction.

To find the diameter of a pump-cylinder to move a given quantity of water per minute (100 feet of piston being the standard of speed), divide the number of gallons by 4, then extract the square root, and the product will be the diameter in inches of the pump-cylinder.

To find quantity of water elevated in one minute running at 100 feet of piston speed per minute, square the diameter of the water-cylinder in inches and multiply by 4. Example: Capacity of a 5-inch cylinder is desired. The square of the diameter (5 inches) is 25, which, multiplied by 4, gives 100, the number of gallons per minute (approximately).

To find the horse-power necessary to elevate water to a given height, multiply the total weight of the water in pounds by the height in feet, and divide the product by 33,000 (an allowance of 25 per cent should be added for water-friction, and a further allowance of 25 per cent for loss in steam-cylinder).

The area of the steam-piston, multiplied by the steam pressure, gives the total amount of pressure that can be exerted. *The area of the water-piston,* multiplied by the pressure of water per square inch, gives the resistance. *A margin* must be made between the *power* and *resistance* to *move* the pistons at the required speed—say from 20 to 40 per cent, according to speed and other conditions.

To find the capacity of a cylinder in gallons. Multiplying the area in inches by the length of stroke in inches will give the total number of cubic inches; divide this amount by 231 (which is the cubical contents of a United States gallon in inches), and product is the capacity in gallons.

To find the height in feet of a column of water corresponding with a given pressure, multiply the pressure in pounds by 2.3 feet.

The following table is arranged to show at a glance the equivalent pressure due to columns of water from 10 to 400 feet in height. Also more particularly to show the number of gallons of water delivered, and the height to which it will be projected through nozzles from ¼ inch to 2 inches in diameter.

GALLONS DELIVERED AND HEIGHT OF WATER PROJECTED FROM NOZZLES.

Height of Column in Feet.	Corresponding Pressure in Pounds per Square Inch.	Diameter of Nozzle in Inches. ¼		½		⅝		¾		1		1¼		1½		1¾			
		Height of Jet in Feet.	Gallons Discharged per Minute.	Height of Jet in Feet.	Gallons Discharged per Minute.	Height of Jet in Feet.	Gallons Discharged per Minute.	Height of Jet in Feet.	Gallons Discharged per Minute.	Height of Jet in Feet.	Gallons Discharged per Minute.	Height of Jet in Feet.	Gallons Discharged per Minute.	Height of Jet in Feet.	Gallons Discharged per Minute.	Height of Jet in Feet.	Gallons Discharged per Minute.	Height of Jet in Feet.	Gallons Discharged per Minute.
10	4.3	9.37	3.6	9.7	14.5	9.7	22.7	9.8	32.8	9.8	58.2	9.9	91	9.9	130.8	9.9	177.6	9.9	232.8
20	8.6	17.5	5.1	18.7	20.6	19	32.2	19.2	46.2	19.4	82.3	19.5	128.4	19.6	184.8	19.6	252	19.7	328.8
30	13.0	24.4	6.4	27.2	25.2	27.7	39.4	28.3	56.8	28.6	100.9	29	157.2	29.1	226.8	29.2	309.6	29.3	403.2
40	17.3	30.0	7.3	35.0	29.5	36	45.5	37	65.5	37.5	116.5	38	182.4	38.3	261.6	38.6	356.4	38.7	465.6
50	21.6	34.0	8.1	42.2	32.5	44	50.9	45	73.3	46.1	130.8	47	204	47.4	292.8	48	408	48	520.8
60	26	37.5	8.9	48.7	35.6	51	55.7	52	80.3	54.4	142.8	55	223.2	56.2	320.4	57	436.8	57	571.2
70	30.3	39	9.6	55	38.5	58	60.1	60	86.8	62.4	154.8	64	241.2	65	346.8	66	471.6	66	616.8
80	34.6	40	10.3	60	41.2	64	64.3	67	92.6	70	164.4	72	258	73	370.8	74	505.2	75	658.8
90	39	39.4	10.9	65	43.7	70	68.3	73	98.4	77	174.0	80	272.4	82	393.6	83	535.2	84	711.6
100	43.3	37.5	11.5	69	46.1	75	72.0	79	103.7	84	183.6	87	288	90	415.2	91	565.2	92	738
120	52	.....	.....	75	50.4	84	78.8	90	113.5	97	201.6	102	315.6	105	453.6	107	626.4	109	807.6
140	60.6	.....	.....	79	54.5	91	85.2	99	122.4	109	217.2	116	340.8	120	490.8	123	668.4	125	872.4
160	69.3	.....	.....	80	58.1	96	90.8	106	131.2	120	232.9	128	364	133	524.2	137	713.5	140	931.9
180	78	.....	.....	78.75	61.6	99	96.5	112	139.1	129	247.1	139	373.2	141	556.1	151	756.9	155	988.6
200	86.6	.....	.....	75	65.2	100	101.8	116	146.4	137	260.4	150	406.8	158	588	166	798	169	1043
220	95.1	.....	.....	.....	.....	99	106.7	119	153.7	145	273.3	159	427.1	165	615	177	837.1	182	1087.6
240	104	.....	.....	.....	.....	96	111.5	120	160.6	150	285.5	168	446.1	180	642.4	189	874.3	195	1142
260	112.6	.....	.....	.....	.....	92	116.0	119.2	167.1	155	297.1	175	464.2	190	668.5	200	909.9	208	1188.4
280	121.2	.....	.....	.....	.....	84	120.4	116.7	173.4	158	308.3	182	481.8	198	693.8	210	944.3	219	1233.4
300	130	.....	.....	.....	.....	75	124.8	112.5	178.8	160	319.2	187	498	206	717.6	220	979.2	230	1276.8
350	151.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	198	538.5	222	775.5	241	1055.5	255	1378.7
400	173.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	200	576	233	829.4	257	1128.9	275	1474.5

The pressure of head water is taken at the nozzle, no allowance being made for friction in the pipe. In practical calculations to determine the height to which water can be thrown, the head consumed by the friction of the water in flowing from the pump to the nozzle must be considered.

WEIGHT OF WATER IN FOOT LENGTHS OF PIPE OF DIFFERENT BORES.*

(62.425 Lbs. Per Cubic Foot.)

Bore, In.	Water, Lbs.	Bore, In.	Water, Lbs.	Bore, In.	Water, Lbs.	Bore, In.	Water, Lbs.
$\frac{1}{8}$	0.0053	3	3.0643	$7\frac{3}{4}$	20.450	17	98.397
$\frac{1}{4}$	0.0213	$3\frac{1}{8}$	3.3250	8	21.790	$17\frac{1}{2}$	104.27
$\frac{3}{8}$	0.0479	$3\frac{1}{4}$	3.5963	$8\frac{1}{4}$	23.174	18	110.31
$\frac{1}{2}$	0.0851	$3\frac{3}{8}$	3.8782	$8\frac{1}{2}$	24.599	$18\frac{1}{2}$	116.53
$\frac{5}{8}$	0.1330	$3\frac{1}{2}$	4.1708	$8\frac{3}{4}$	26.068	19	122.91
$\frac{3}{4}$	0.1915	$3\frac{5}{8}$	4.4741	9	27.579	$19\frac{1}{2}$	129.47
$\frac{7}{8}$	0.2607	$3\frac{3}{4}$	4.7879	$9\frac{1}{4}$	29.132	20	136.19
1	0.3405	$3\frac{7}{8}$	5.1125	$9\frac{1}{2}$	30.728	21	150.15
$1\frac{1}{8}$	0.4309	4	5.4476	$9\frac{3}{4}$	32.366	22	164.79
$1\frac{1}{4}$	0.5320	$4\frac{1}{4}$	6.1498	10	34.048	23	180.11
$1\frac{3}{8}$	0.6437	$4\frac{1}{2}$	6.8946	$10\frac{1}{2}$	37.537	24	196.11
$1\frac{1}{2}$	0.7661	$4\frac{3}{4}$	7.6820	11	41.198	25	212.80
$1\frac{5}{8}$	0.8997	5	8.5119	$11\frac{1}{2}$	45.028	26	230.16
$1\frac{3}{4}$	1.0427	$5\frac{1}{4}$	9.3844	12	49.028	27	248.21
$1\frac{7}{8}$	1.1970	$5\frac{1}{2}$	10.299	$12\frac{1}{2}$	53.199	28	266.93
2	1.3619	$5\frac{3}{4}$	11.257	13	57.540	29	286.34
$2\frac{1}{8}$	1.5375	6	12.257	$13\frac{1}{2}$	62.052	30	306.43
$2\frac{1}{4}$	1.7237	$6\frac{1}{4}$	13.300	14	66.733	31	327.20
$2\frac{3}{8}$	1.9205	$6\frac{1}{2}$	14.385	$14\frac{1}{2}$	71.585	32	348.65
$2\frac{1}{2}$	2.1280	$6\frac{3}{4}$	15.513	15	76.607	33	370.78
$2\frac{5}{8}$	2.3461	7	16.683	$15\frac{1}{2}$	81.799	34	393.59
$2\frac{3}{4}$	2.5748	$7\frac{1}{4}$	17.896	16	87.162	35	417.08
$2\frac{7}{8}$	2.8142	$7\frac{1}{2}$	19.152	$16\frac{1}{2}$	92.694	36	441.26

Weights of water in cylinders of the same length are proportional to the squares of the diameters. Therefore, to get weight of cylinder of water one foot long and 60 inches diameter, take from above table weight of water of 30-inch pipe and multiply it by the square of 60 ÷ 30, or the square of two, thus: $306.43 \times 4 = 1225.72$ = the weight of water in one-foot length of a 60-inch pipe.

* Also see table on page 235.

WEIGHT AND CAPACITY OF DIFFERENT STANDARD GALLONS OF WATER.

	Cubic Inches in a Gallon.	Weight of a Gallon in Pounds.	Gallons in a Cubic Foot.
Imperial or English.	277.274	10.00	6.232102
United States.	231	8.33111	7.480519

DISCHARGE OF WATER IN PIPES.

For any Length and Head, and for Diameters from 1 Inch to 10 Feet, in Cubic Feet per Minute.—(Beardmore.)

Diameter. Ft.	Ins.	Tabular Number.	Diameter. Ft.	Ins.	Tabular Number.	Diameter. Ft.	Ins.	Tabular Number.
	1	4.71	1	7	7433	3	7	57265
	1.25	8.48	1	8	8449	3	8	60648
	1.5	13.02	1	9	9544	3	9	64156
	1.75	19.15	1	10	10722	3	10	67782
	2	26.69	1	11	11983	3	11	71526
	2.5	46.67	2		13328	4		75392
	3	73.5	2	1	14758	4	3	87730
	3.5	108.14	2	2	16278	4	6	101207
	4	151.02	2	3	17889	4	9	115854
	4.5	194.84	2	4	19592	5		131703
	5	263.87	2	5	21390	5	3	148791
	6	416.54	2	6	23282	5	6	167139
	7	612.32	2	7	25270	5	9	186786
	8	654.99	2	8	27358	6		207754
	9	1147.6	2	9	29547	6	6	253781
	10	1493.5	2	10	31834	7		305437
	11	1894.9	2	11	34228	7	6	362935
1		2356	3		36725	8		426481
1	1	2876.7	3	1	39329	8	6	496275
1	2	3463.3	3	2	42040	9		572508
1	3	4115.9	3	3	44863	9	6	655369
1	4	4836.9	3	4	47794	10		745038
1	5	5628.5	3	5	50835			
1	6	6493.1	3	6	53995			

This table is applicable to sewers and drains by taking same proportion of tabular numbers that area of cross-section of water in sewer or drain bears to whole area of sewer or drain.

To Compute Volume Discharged when Length of Pipe, Height or Fall, and Diameter are Given.—*Rule.*—Divide tabular number, opposite to diameter of tube, by square root of rate of inclination, and quotient will give volume required in cubic feet per minute.

Example.—A pipe has a diameter of 9 inches, and a length of 4750 feet; what is its discharge per minute under a head of 17.5 feet?

Tab. No. 9 in. $=1147.6$, and $\dfrac{1147.61}{\sqrt{\dfrac{4750}{17.5}}}=\dfrac{1147.61}{16.47}=69.67$ cubic feet.

TO COMPUTE DIAMETER WHEN LENGTH, HEAD, AND VOLUME ARE GIVEN.—*Rule.*—Multiply discharge per minute by square root of ratio of inclination; take nearest corresponding number in table, and opposite to it is diameter required.

Example.—Take elements of preceding case.

$$69.67\times\sqrt{\frac{4750}{17.5}}=1147.61, \text{ and opposite to this is 9 inches.}$$

Or, $\sqrt[5]{\frac{vl}{1542h}}=d$ in feet; v representing velocity in feet per second, and l length in feet.

TO COMPUTE HEAD WHEN LENGTH, DISCHARGE, AND DIAMETER ARE GIVEN.—*Rule.*—Divide tabular number for diameter by discharge per minute, square quotient, and divide length of pipe by it; quotient will give head necessary to force given volume of water through pipe in one minute.

Example.—Take elements of preceding cases:

$$\frac{1147.61}{69.67}=16.47;\ 16.47^2=271.3;\ 4750\div 271.2=17.5 \text{ feet.}$$

TO COMPUTE VELOCITY WHEN VOLUME AND DIAMETER ALONE ARE GIVEN.—*Rule.*—Divide volume when in feet per minute by area in feet, and quotient, divided by 60, will give velocity in feet per second.

Example.—Take elements of preceding case:

$$\frac{69.67}{0.75^2\times 0.7854}\div 60=2.63 \text{ feet.}$$

WHEN VOLUME IS NOT GIVEN —*Rule.*—Multiply square root of product of height of pipe by diameter in feet, divided by length in feet, by 50, and product will give velocity in feet per second. (Beardmore.)

TO COMPUTE INCLINATION OF PIPE WHEN VOLUME, DIAMETER, AND LENGTH ARE GIVEN: $\left\{\frac{V}{2356}\right\}^2\frac{1}{D^5}=\frac{H}{L}$.

Illustration.—Take elements of preceding case:

$$\left\{\frac{69.67}{2356}\right\}^2\times\frac{1}{0.75^5}=0.000847\times 4.214=0.00368,$$

and

$$\frac{17.5}{4750}=0.00368, \quad \text{or} \quad 4750\times 0.00368=17.49 \text{ ft. head.}$$

Sewers, etc.

The system of drainage pipes within a building is usually called soil pipes, or house drains, but after the pipes pass outside the building they are called sewers.

In nearly all the large cities the building codes compel the use of cast-iron pipe within the buildings, but after passing to the outside of the building various kinds of pipe are used, the majority of the small sewers being made with what is known as vitrified salt glazed sewer pipe. These pipes make an excellent sewer when certain precautionary measures are taken when the pipes are laid.

The efficiency of all pipe sewers, whether private or public, depends on the care with which they are laid. The objects to be aimed at when laying pipe sewers are tight joints, true grades, generous curves, the least possible disturbance of the flow at the numerous inlets, and laid on the greatest possible inclination.

Excavation. — Commence at the lower end or outlet of the proposed drain or sewer, and make the trench of uniform, gradual, and continuous inclination, and distribute the whole available fall over the entire length of the sewer. After bringing the bottom of the trench to a uniform grade, cut out of the bottom of the trench holes or pockets for the hubs of the pipes to set in; these hubs should be free and the pipe should be carried by its body resting on the bottom of the trench. If the ground is of a rocky or rough nature a layer of sand should be spread on the bottom of the trench and the pipe set in this sand, so that each length of pipe has a solid bed. The pipe will sustain the greatest amount of vertical pressure when it has a firm and uniform bearing at all points on its lower surface.

Inclination. — The object of giving an inclination or fall to a sewer is to secure the velocity necessary for the removal of such solid matters as may exist in the sewage. A fall of 1 in 40 to 1 in 60 is desirable for pipes of 4 to 6 inches in diameter, and greater if attainable.

A grade of 1 in 90 is the least that should be given to small house drains, in order to make them self cleansing. Large pipes require less fall than small ones. A well-constructed 18-inch pipe sewer, on a grade of 1 in 1000 running half full, will be self cleansing.

The sewer should have a straight and uniform fall its entire length so that the water and sewage will have the same velocity the entire length of the sewer, the depth of which should be sufficient to float and carry along any solid matter that will enter the sewer.

The sewer should be large enough to carry the largest amount of water that may enter it at any one time, yet it must not be so

Fig. 65. Sewer with sufficient water to be self cleansing.

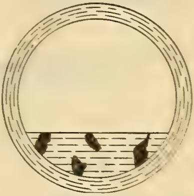


Fig. 66. Sewer with not sufficient water to be self cleansing.

large that at the time of the ordinary flow of water the water will be too shallow to carry the solids. Fig. 65 shows a sewer running about half full, which will carry along all solid matter as shown; Fig. 66 shows the same sewer with not enough water to carry the solids, which will leave a deposit of slime and dirt along the inside of the sewer.

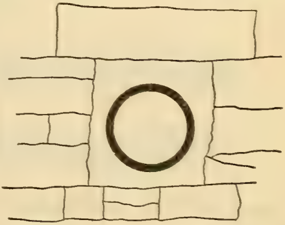


Fig. 67. Opening in Wall for Sewer Pipe.

When a sewer or drain passes through a wall, the opening should be made large enough so that in case of settlement of the wall or building no weight will come upon the pipe; Fig. 67 shows how such an opening should be constructed and covered with a lintel or cap stone.

Mode of Laying. — Commence laying the pipe at the end or outlet with the hubs all facing up grade; lay with a perfectly true line of fall from point to point of the sewer, and give each pipe a uniform bearing throughout its whole length. Each and every joint of pipe should have a secure and solid bed so there will be no settlement to break the pipe or cause displacement as shown by Fig. 68, thus making a pocket in the sewer.

The ends of each length of pipe should abut squarely and truly against the adjoining pieces, so as to present an absolute continuity and uniformity in the interior of the drain, particularly at the bottom line. The space between the spigot and hub end of the pipe should be filled with cement mortar, which should be pressed into place with the fingers. In cementing the joints

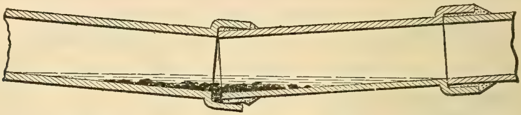


Fig. 68. Pocket in Sewer caused by settlement.

especial care should be exercised to see that the cement does not ooze out into the interior of the pipe. A careless workman will often make the joint as shown at *A*, Fig. 69, leaving a ridge of cement around the inside of the pipe, which will retard the flow of the sewage and cause the pipe to fill with sediment; the joint should be left as shown at *B*.

As each piece of pipe is laid in position, the inside of the pipe around the joint should be wiped out clean as shown by *B*, Fig. 69.

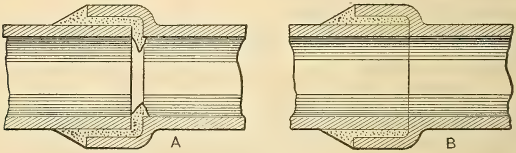


Fig. 69. Good and poor cement joints in Sewer Pipe.

If it is a small pipe, fasten a rag on the end of a stick and run it into the pipe, wiping out the surplus cement mortar that may have oozed out of the joint.

A good method of joining the pipes so as to prevent the cement from protruding into the pipe, and to secure a concentric bore at the joints, is to force into the hub between the hub and spigot several strands of tarred hemp or oakum of sufficient diameter to fit the hub tightly. It should be forced into the hub with a calking tool, and then the cement joint made in the usual way. If this method of using gaskets is not used in laying the pipes,

the interior of each joint should be swabbed out after cementing as previously described.

Cement Mortar. — The cement mortar employed to make the joints should be in the proportion of one part cement to two parts clean, sharp sand. The cement and sand should be carefully mixed dry, and the water afterwards added, mixing just what will be used immediately, and not allowed to stand until it sets. Any amount can be mixed dry, but just enough to make five or six joints should be wet and mixed at one time.

Connection of Branch and Main. — When a small sewer or drain connects with and enters a larger one the connection should be made with a Y branch as shown by Fig. 70, which should be turned up so the inlet will be near the top of the large sewer and above the water line of the sewer. See page 256 for the various fittings made for vitrified pipe.

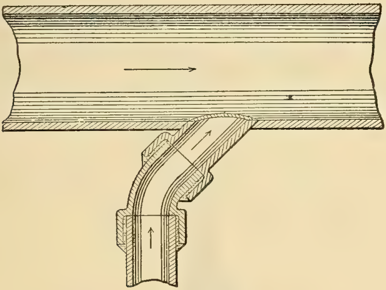


Fig. 70. Y Branch Connection.

Joints of Cast Iron Soil and Sewer Pipe. — The joints of cast iron soil pipe are usually made with lead, and should be run and calked so as to be water and air tight.

The space between the spigot and the hub of the pipe should be calked with a ring of oakum of good quality. This oakum should be pulled apart and then twisted into a short rope just long enough to reach around the pipe and thick enough to fill the space in the joint. This rope of oakum is wrapped around the spigot end of the pipe and calked into the hub. It should be calked so that it holds the spigot in the center of the hub, and is tight enough to prevent the hot lead from running through.

The lead should be hot enough and melted in sufficient quantity

to pour the joint without cooling. The lead should be run so that it comes a little above the rim of the hub so that there will be sufficient for calking, and after being calked the hub will be entirely filled.

The lead for running the joints should be of a soft quality so it will expand under the calking tool.

Asphalt Pipe Joints. — The joints of vitrified sewer pipe are usually made with cement as previously explained, but asphalt and sulphur have been used successfully for this purpose.

In England and Germany asphalt has been used extensively, and with good success, for making joints of sewer pipe. The joint is calked and prepared as for running lead, and the hot asphalt run in.

As a test in one instance a long stretch of pipe was laid, and after making the joints the two ends were plugged, and the trench allowed to fill with water. The result was that the pipe floated, showing that the joints were both flexible and water tight.

Sulphur Joints. — At West Orange, N.J., sulphur was used successfully for making the joints of a sewer system. The sulphur is heated in an ordinary ladle, and by tests it has been found

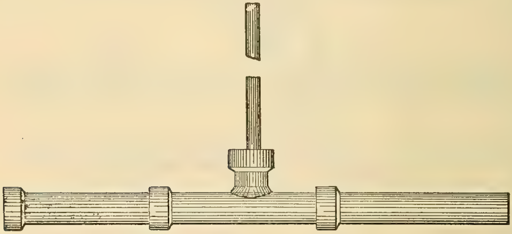


Fig. 71. Hydraulic Test of Sewer System.

that the strongest mixture is equal parts of sulphur and sand. A sulphur composition called " Pozite " is sold by F. H. Pough, New York. It is a mixture of sulphur and sand.

Filling the Trench. — As fast as the filling is deposited in the trench (the sand or fine dirt first), it should be thoroughly puddled and tamped, especially under and around the lower half of the pipe, and to such an extent as to render the subsequent settlement of the filling impossible.

Testing Vitrified Pipe Sewer. — If at any time vitrified pipe is used for drainage inside a building, the system, after being laid and the cement in the joints hard, should be subjected to a water test as follows; this test can be made in about a week after the pipe is laid, as the cement in the joints will then be hard enough to withstand the pressure.

Plug all the openings of the sewer except one, which should be a tee or branch; in this opening insert and make tight a standpipe of sufficient height to give the desired water pressure for the test as shown by Fig. 71 (see page 220 for pressure of water at various heights).

After this pipe is put in place fill the entire line with water until it overflows at the top of the standpipe. Let the water stand for awhile and then examine all joints, etc., for leaks. A valve and connection can be put in the standpipe so that a hose can be attached for filling the line.

QUANTITY OF CEMENT, ETC., REQUIRED FOR LAYING SEWER PIPE.

Table prepared by J. N. Hazlehurst, M. Am. Soc. C. E., Atlanta, Ga.

Quantities of Cement, Sand, and of Cement Mortar, for Sewer Pipe Joints.

For each 100 feet of sewer (with Portland Cement 375 pounds net per bbl).

			Proportions: 1 Cement to					
			1 sand			2 sand		
Size of Pipe.	Length, Feet.	Mortar, Cu. Yds.	Cement, Bbls.	Sand, Cu. Yd.	No. Ft. to Bbl. Cemt.	Cement, Bbls.	Sand, Cu. Yd.	No. Ft. to Bbl. Cemt.
6-in.	$2\frac{1}{2}$	0.003	0.01248	0.00201	803	0.00855	0.00252	1,168
8-in.	$2\frac{1}{2}$	0.038	0.15808	0.02546	633	0.10830	0.03192	923
10-in.	$2\frac{1}{2}$	0.058	0.24128	0.03886	410	0.16530	0.04872	605
12-in.	$2\frac{1}{2}$	0.089	0.37024	0.05963	270	0.25365	0.07476	394
15-in.	$2\frac{1}{2}$	0.123	0.51268	0.08241	195	0.35055	0.10332	285
18-in.	$2\frac{1}{2}$	0.167	0.69472	0.11189	144	0.47595	0.14018	210
20-in.	$2\frac{1}{2}$	0.237	0.98592	0.15879	101	0.67545	0.19908	148
24-in.	$2\frac{1}{2}$	0.299	1.24384	0.20033	80	0.85215	0.25116	117
27-in.	3	0.492	2.04672	0.32964	49	1.40220	0.41328	71
30-in.	3	0.548	2.27968	0.36716	44	1.56180	0.46032	64
36-in.	3	0.849	3.53184	0.56883	29	2.41965	0.71316	41

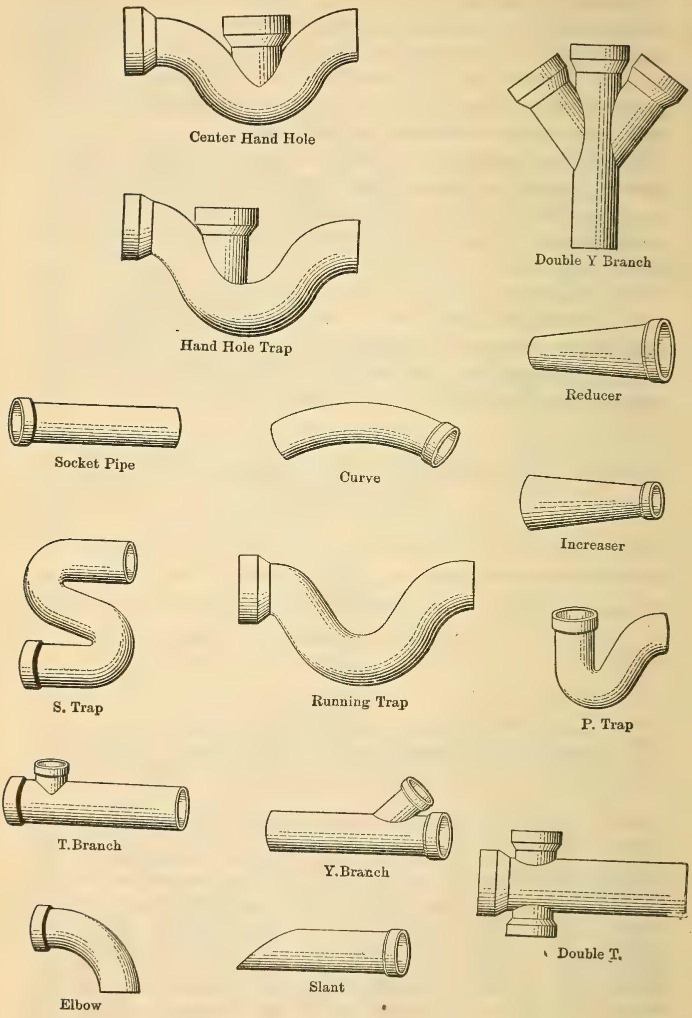


Fig. 72. Sewer Pipe Fittings.

Cleaning Sewers. — It is an important condition of all properly constructed sewers that they should at all times be kept free from sedimentary deposits, and from the adhesion of foul and slimy matter to their side walls.

An effective way to remove sedimentary deposits from large pipe sewers is as follows: A wooden ball about 2 inches smaller than the size of the pipe sewer to be cleaned is introduced into the sewer through the manhole. The ball floats against the top or crown of the sewer, thus making a sort of a dam and partially retarding the flow of water. The water held back in this manner will force the ball along; at the same time the water is running under the ball with great force, cutting away any deposits that may have accumulated on the bottom of the sewer. The deposits are carried away by the water to the manhole below, where they can be removed. A rope is attached to the ball so that in case there are any obstructions in the sewer which the ball cannot force out, or if the sewer has settled, as is sometimes the case, by means of this rope the ball can be drawn back to the starting-point. By measuring the length of the rope that was in the sewer the exact location of the obstruction can be located, without digging up the whole length of the sewer. When cleaning sewers with the ball, commence at the highest point of the sewer and work towards the outlet.

Inclination or Fall of Sewers. — All sewers should have the greatest possible fall or inclination. The greater the fall, the greater is the velocity. In order to prevent deposits in sewers, it is necessary to provide a certain velocity in the flow of sewage, which must be secured throughout the whole system of sewers, and such velocity must be sufficient to prevent any settlement of and to move along the sewer any solid matter.

To effect this, 2 feet per second for street sewers, and 3 feet per second for house drains, is considered the minimum velocity.

The greater the velocity, the greater is the carrying capacity of the sewer.

FALL AT WHICH HOUSE DRAINS SHOULD BE LAID.

Diameter of pipe, inches	2	3	4	5	6	7	8	9	10
Length to 1 foot of fall, feet	20	30	40	50	60	70	80	90	100

The following table gives the inclination and velocity of sewers running full or half-full.

INCLINATION OF CIRCULAR SEWERS FOR VELOCITIES FROM TWO TO FOUR FEET PER SECOND, RUNNING FULL OR HALF FULL.

Diameter in Inches.	Velocity, 2 Feet per Second.	Velocity, 2.5 Feet per Second.	Velocity, 3 Feet per Second.	Velocity, 3.5 Feet per Second.	Velocity, 4 Feet per Second.
3	1 in 145	1 in 96	1 in 68	1 in 51	1 in 39
4	" 194	" 129	" 92	" 68	" 53
5	" 243	" 160	" 115	" 85	" 66
6	" 292	" 193	" 137	" 102	" 80
8	" 389	" 257	" 183	" 137	" 106
10	" 486	" 322	" 229	" 171	" 133
12	" 583	" 386	" 275	" 205	" 159
14	" 685	" 452	" 322	" 241	" 187
16	" 777	" 513	" 366	" 273	" 212
18	" 875	" 579	" 412	" 307	" 239
20	" 972	" 643	" 458	" 342	" 265
22	" 1069	" 708	" 504	" 376	" 292
24	" 1166	" 772	" 550	" 410	" 318

DATA FOR FLUMES AND DITCHES. — To give a general idea as to the capacity of flumes and ditches for carrying water, the following data are given.

The greatest safe velocity for a wooden flume is about 7 or 8 feet per second. For an earth ditch this should not exceed about 3 feet per second. In California it is the general practice to lay a flume on a grade of about $\frac{1}{4}$ inch to the rod, or often 2 inches to the 100 feet, depending on the existing conditions.

Assuming a rectangular flume 3 feet wide, running 18 inches deep, its velocity and capacity would be as follows:

Grade.	Velocity in Feet per Second.	Quantity Cubic Feet per Minute.
$\frac{1}{8}$ inch to the rod	2.6	702
$\frac{1}{4}$ inch to the rod	3.7	999
$\frac{1}{2}$ inch to the rod	5.3	1,431

As the velocity in a flume or ditch is dependent largely on its size and character of formation, only approximate data can be given.

It is not safe to run either ditch or flume more than about three-fourths or seven-eighths full.

Fall to produce a Current. — A fall of 3 inches per mile in a river will create a current, and produce a velocity of about 3 miles per hour.

Carrying Capacity of Sewers Used for Surface Drainage. — When the area to be drained and the fall of the sewer are known, the size of the pipe required can be easily ascertained by referring to the following table, which gives the number of cubic feet discharged per minute by specified sizes and grades. In main sewers this flow, of course, is greatly increased by the added pressure of the connecting branches.

Statistics show the maximum rainfall to be about one inch per hour, except during very heavy and uncommon storms.

One inch rainfall per hour gives 3630 cubic feet per hour for each acre, or 60.5 cubic feet per minute per acre.

Experience shows that owing to various obstructions, not over 50 or 75 per cent of the rain falling will reach the sewer within the same hour. Due allowance should be made for this fact in determining the size of pipe required, as severe storms are of usually short duration.

Velocity of Water in Sewers and Pipes. — When running half full of water the velocity in sewers and pipes will be about the same as when running full.

As the water increases in volume over half filling the pipe the velocity increases until the pipe is filled to .9 of its diameter, when at this point the velocity is about 10 per cent greater than when the pipe is either half full or full. When the pipe is filled to a depth of one quarter its diameter the velocity is about 75 per cent of that when full or half full.

THE FOLLOWING TABLE GIVES THE DISCHARGING CAPACITY OF CIRCULAR SEWERS AT VARIOUS INCLINATIONS.

* In Cubic Feet per Minute.

Inclination.	Size, 4 In.	Size, 6 In.	Size, 8 In.	Size, 10 In.	Size, 12 In.	Size, 14 In.	Size, 16 In.	Size, 18 In.	Size, 20 In.	Size, 22 In.	Size, 24 In.
1 in 50, or 105 feet per mile......	21.48	60.17	123.5	214	339	474	663	927	......	......	......
1 in 60, or 88 feet per mile......	19.73	54.68	112.7	196	310	434	607	849	......	......	......
1 in 70, or 75 feet per mile......	18.25	50.37	104.0	182	287	401	561	788	......	......	......
1 in 80, or 66 feet per mile......	16.94	46.84	97.02	170	268	375	525	738	......	......	......
1 in 90, or 58 feet per mile......	15.89	44.10	91.44	160	252	352	492	696	......	......	......
1 in 100, or 52 feet per mile......	15.02	41.75	86.55	152	240	336	470	660	859	1090	1357
1 in 110, or 48 feet per mile......	14.23	39.59	82.36	144	228	319	446	630	820	1043	1298
1 in 120, or 44 feet per mile......	13.53	37.83	78.52	137	218	305	427	604	785	997	1241
1 in 130, or 40 feet per mile......	13.01	36.46	75.38	132	209	292	408	579	755	958	1191
1 in 140, or 37 feet per mile......	12.48	34.89	72.59	127	201	281	393	558	728	924	1147
1 in 150, or 35 feet per mile......	12.05	33.71	70.15	122	194	271	379	540	702	892	1109
1 in 160, or 33 feet per mile......	11.61	32.54	67.71	118	188	263	368	523	680	863	1075
1 in 170, or 31 feet per mile......	11.26	31.36	65.61	115	182	254	355	507	661	836	1043
1 in 180, or 29 feet per mile......	10.91	30.38	63.52	111	176	246	344	491	641	813	1012
1 in 190, or 27 feet per mile......	10.56	29.60	61.77	108	171	240	336	477	624	792	983
1 in 200, or 26 feet per mile......	10.36	28.81	60.03	105	167	233	326	464	606	770	958
1 in 250, or 21 feet per mile......	......	25.68	53.40	93	148	207	289	413	539	686	854
1 in 300, or 17 feet per mile......	......	23.13	48.16	85	135	189	264	376	491	625	779

* There are 7.4805 gallons in a cubic foot.

CAPACITY OF DRAIN TILE.

Numbers of Acres which Tiles of the following Sizes and Inclinations will Drain when the Rain-fall does not exceed Half an Inch in Twenty-four Hours.

Inclination.	2 Inch Tile.	3 Inch Tile.	4 Inch Tile.	5 Inch Tile.	6 Inch Tile.	8 Inch Tile.	10 Inch Tile.	12 Inch Tile.
1 ft. in:								
10	6.6	18.9	......	......	......	......	......	......
20	4.7	13.	26.8	47.2	......	......	......	......
25	4.2	11.4	24.	44.4	66.2	......	......	......
30	3.9	10.9	21.9	41.2	61.5	126.4	......	......
40	3.4	9.4	19.	36.1	53.3	109.6	190.5	......
50	3.	8.4	17.	30.4	47.7	98.	170.4	269.
60	2.7	7.6	15.6	29.1	43.4	90.	156.	246.
70	2.5	6.9	14.5	26.5	39.9	83.	144.4	228.1
80	2.3	6.5	13.4	23.6	37.2	77.	135.	213.
90	2.2	6.1	12.6	23.1	35.	72.5	127.	200.5
100	2.	5.7	11.9	21.2	33.1	69.2	120.6	190.5
150	1.6	4.5	9.5	19.2	26.6	56.	97.3	154.4
200	......	3.9	8.2	15.2	22.8	48.	83.9	132.5
250	......	3.5	7.5	13.4	20.4	43.4	74.4	117.
300	......	......	6.9	12.3	18.4	38.2	65.5	107.
400	......	......	5.9	10.6	16.5	34.6	60.3	90.7
500	......	......	5.3	9.6	14.8	30.1	54.	81.6
600	......	......	4.8	9.	13.3	28.	48.6	74.
800	......	......	4.1	7.6	11.4	24.	41.9	65.
1,000	......	......	......	6.7	10.2	21.2	37.2	56.
1,500	......	......	......	......	8.7	17.6	30.8	47.
2,000	......	......	......	......	......	......	27.	40.8

NOTE. — One acre covered with water one-half inch in depth is equivalent to 1815 cubic feet, or 13,577 gallons. The capacity of the tile can be expressed in cubic feet or gallons by multiplying the number of acres drained by either 1815 or 13,577.

Excavation Tables, Useful for Finding the Cubical Contents of Excavations for Sewers, etc.

The following tables on pages 262 to 267 give the cubical contents in yards for each foot in depth of various trenches and excavations. Example: Find the number of yards in a trench 2 feet wide, 60 feet long, and 4 feet deep. On page 264 we find 2 in the column of widths and follow this column down until we come to the length 60, where we find 4.4 or 4.4 cubic yards for each foot of depth; multiplying this by 4 gives the cubical contents of the trench as 17.6 cubic yards; if the trench to be figured is longer than 65 feet, divide it into two or more lengths and find the contents of each section separately.

NUMBER OF CUBIC YARDS IN AN EXCAVATION OR CELLAR TO EACH FOOT IN DEPTH.

From 2×6 to 16×35.

Length in Feet.	Width in Feet.															Length in Feet.
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
6	.4	.7	.9	1.1	1.3	1.5	1.7	2	2.2	2.4	2.6	2.9	3.1	3.3	3.5	6
7	.5	.8	1	1.3	1.5	1.8	2	2.4	2.6	2.8	3.1	3.4	3.6	3.9	4.1	7
8	.6	.9	1.2	1.5	1.8	2	2.4	2.6	3	3.2	3.5	3.8	4.1	4.4	4.7	8
9	.7	1	1.3	1.6	2	2.4	2.6	3	3.4	3.7	4	4.3	4.7	5	5.3	9
10	.7	1.1	1.5	1.8	2.2	2.6	3	3.4	3.7	4.1	4.4	4.8	5.2	5.5	5.9	10
11	.8	1.2	1.6	2	2.4	2.8	3.2	3.7	4.1	4.4	4.8	5.2	5.7	6.1	6.5	11
12	.9	1.3	1.8	2.2	2.6	3	3.5	4	4.4	4.8	5.2	5.7	6.2	6.6	7.1	12
13	1	1.4	1.9	2.4	2.9	3.4	3.8	4.3	4.8	5.2	5.7	6.2	6.7	7.2	7.8	13
14	1	1.5	2	2.5	3.1	3.6	4.1	4.7	5.2	5.7	6.2	6.7	7.2	7.8	8.3	14
15	1.1	1.7	2.2	2.7	3.3	3.9	4.4	5	5.5	6.1	6.7	7.2	7.8	8.3	8.9	15
16	1.2	1.8	2.3	2.9	3.5	4.1	4.7	5.3	5.9	6.5	7.1	7.8	8.3	8.9	9.5	16
17	1.3	1.9	2.5	3.1	3.8	4.4	5	5.7	6.3	6.9	7.5	8.1	8.8	9.4	10.1	17
18	1.3	2	2.6	3.3	4	4.6	5.3	6	6.6	7.3	8	8.6	9.3	10	10.6	18
19	1.4	2.1	2.8	3.5	4.2	4.9	5.6	6.3	7	7.7	8.4	9.1	9.8	10.4	11.2	19
20	1.5	2.2	2.9	3.7	4.4	5.2	5.9	6.6	7.4	8.1	8.8	9.5	10.3	11	11.8	20
21	1.5	2.3	3.1	3.9	4.5	5.3	6.2	7	7.8	8.5	9.2	10	10.8	11.6	12.4	21
22	1.6	2.4	3.2	4.1	4.9	5.7	6.5	7.3	8.1	8.9	9.7	10.5	11.4	12.2	13	22
33	1.7	2.5	3.4	4.2	5.1	5.9	6.8	7.6	8.5	9.3	10.2	11	11.9	12.7	13.6	23
24	1.8	2.6	3.5	4.4	5.2	6.1	7.1	8	8.8	9.7	10.7	11.5	12.4	13.3	14.2	24
25	1.8	2.7	3.6	4.6	5.5	6.4	7.4	8.3	9.2	10.1	11.1	12	12.9	13.8	14.8	25
26	1.9	2.9	3.8	4.8	5.8	6.7	7.7	8.6	9.6	10.6	11.5	12.5	13.5	14.4	15.4	26
27	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	27
28	2.1	3.1	4.1	5.1	6.2	7.3	8.3	9.3	10.3	11.4	12.4	13.5	14.5	15.5	16.6	28
29	2.1	3.2	4.3	5.3	6.4	7.5	8.5	9.6	10.7	11.8	12.9	14	15	16.1	17.2	29
30	2.2	3.4	4.4	5.5	6.6	7.7	8.8	10	11.1	12.2	13.3	14.4	15.5	16.6	17.7	30
31	2.3	3.4	4.6	5.7	6.8	8	9.2	10.3	11.5	12.6	13.7	14.9	16	17.1	18.3	31
32	2.4	3.5	4.7	5.9	7.1	8.3	9.5	10.6	11.8	13	14.2	15.4	16.6	17.7	18.9	32
33	2.4	3.6	4.9	6.1	7.3	8.5	9.8	11	12.2	13.4	14.6	15.9	17.1	18.2	19.5	33
34	2.5	3.7	5	6.3	7.5	8.8	10.1	11.4	12.6	13.8	15.1	16.3	17.6	18.8	20.1	34
35	2.6	3.9	5.1	6.5	7.8	9	10.4	11.7	13	14.2	15.5	16.7	18	19.2	20.7	35

NUMBER OF CUBIC YARDS IN AN EXCAVATION OR CELLAR TO EACH FOOT IN DEPTH—(*Continued*).
FROM 17×6 TO 30×35.

Length in Feet.	Width in Feet.														Length in Feet.
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
6	3.8	4	4.2	4.4	4.5	4.9	5.1	5.2	5.5	5.8	6	6.2	6.4	6.6	**6**
7	4.4	4.6	4.9	5.2	5.3	5.7	5.9	6.1	6.4	6.7	7	7.3	7.5	7.7	**7**
8	5	5.3	5.6	5.9	6.2	6.5	6.8	7.1	7.4	7.7	8	8.3	8.5	8.8	**8**
9	5.7	6	6.3	6.6	7	7.3	7.6	8	8.3	8.6	9	9.3	9.6	10	**9**
10	6.3	6.6	7	7.4	7.8	8.1	8.5	8.8	9.2	9.6	10	10.3	10.7	11.1	**10**
11	6.9	7.3	7.7	8.1	8.5	8.9	9.3	9.7	10.1	10.6	11	11.4	11.8	12.2	**11**
12	7.5	8	8.4	8.8	9.2	9.7	10.2	10.7	11.1	11.5	12	12.4	12.9	13.2	**12**
13	8.1	8.6	9.1	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.4	**13**
14	8.8	9.3	9.8	10.3	10.8	11.4	11.9	12.4	13.9	13.5	14	14.5	15	15.5	**14**
15	9.4	10	10.4	11	11.6	12.2	12.7	13.3	13.8	14.4	15	15.5	16.1	16.6	**15**
16	10.1	10.6	11.2	11.8	12.4	13	13.6	14.2	14.8	15.4	16	16.6	17.2	17.7	**16**
17	10.7	11.3	11.9	12.5	13.3	13.8	14.4	15.1	15.7	16.3	17	17.7	18.3	18.8	**17**
18	11.3	12	12.6	13.3	14	14.7	15.3	16	16.7	17.3	18	18.7	19.3	20	**18**
19	11.9	12.6	13	14.1	14.7	15.5	16.1	16.8	17.5	18.3	19	19.7	20.3	21.1	**19**
20	12.5	13.3	14.1	14.8	15.5	16.3	17	17.7	18.4	19.2	20	20.7	21.4	22.2	**20**
21	13.3	14	14.7	15.5	16.3	17.1	17.9	16.6	19.3	20.1	21	21.7	22.5	23.3	**21**
22	13.8	14.7	15.5	16.3	17.1	18	18.8	19.5	20.3	21.1	22	22.8	23.6	24.4	**22**
23	14.4	15.3	16.1	17	17.9	18.8	19.6	20.4	21.2	22.1	23	23.8	24.6	25.5	**23**
24	15.1	16	16.8	17.7	18.6	19.5	20.4	21.3	22.2	23.1	24	24.9	25.7	26.6	**24**
25	15.7	16.7	17.5	18.4	19.3	20.3	21.2	22.2	23.1	24	25	25.9	26.8	27.7	**25**
26	16.3	17.3	18.3	19.2	20.1	21.1	22.1	23.1	24	25	26	27	27.9	28.9	**26**
27	17	18	19	20	21	22	23	24	25	26	27	28	29	30	**27**
28	17.7	18.7	19.7	20.7	21.7	22.8	23.8	24.9	25.9	27	28	29	30	31.1	**28**
29	18.3	19.3	20.3	21.4	22.5	23.6	24.6	25.7	26.8	27.9	29	30	31.1	32.2	**29**
30	18.8	20	21.1	22.2	23.3	24.4	25.5	26.6	27.7	28.9	30	31.1	32.2	33.3	**30**
31	19.4	20.7	21.7	22.9	24	25.1	26.3	27.5	28.3	29.8	31	32.1	33.2	34.4	**31**
32	20.1	21.4	22.5	23.7	24.8	25.9	27.2	28.4	28.9	30.8	32	33.1	34.3	35.5	**32**
33	20.7	22	23.2	24.4	25.6	26.8	28.1	29.3	29.6	31.7	33	34.2	35.4	36.6	**33**
34	21.4	22.7	23.9	25.1	26.4	27.7	29	30.2	31.4	32.7	34	35.2	36.5	37.7	**34**
35	22	23.3	24.6	25.9	27.2	28.6	29.9	31.1	32.2	33.6	35	36.2	37.5	38.8	**35**

NUMBER OF CUBIC YARDS IN AN EXCAVATION OR CELLAR TO EACH FOOT IN DEPTH—(*Continued*).

FROM 2×36 TO 16×65.

Length in Feet.	Width in Feet. 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Length in Feet.
36	2.6	4	5.3	6.6	8	9.3	10.6	12	12.3	14.6	16	17.3	18.6	20	21.3	36
37	2.7	4.1	5.5	6.8	8.2	9.6	10.9	12.3	12.7	15	16.4	17.8	19.1	20.5	21.9	37
38	2.8	4.2	5.6	7	8.4	9.8	11.2	12.6	14	15.4	16.8	18.3	19.7	21.1	22.5	38
39	2.8	4.3	5.8	7.2	8.6	10.1	11.5	13	14.4	15.8	17.3	18.8	20.2	21.6	23.1	39
40	2.9	4.4	5.9	7.4	8.8	10.3	11.[illegible]	13.3	14.8	16.2	17.7	19.2	20.7	22.2	23.7	40
41	3	4.5	6.1	7.6	9	10.6	12.1	13.6	15.2	16.6	18.1	19.7	21.2	22.7	24.3	41
42	3.1	4.6	6.2	7.7	9.3	10.8	12.4	14	15.5	17.1	18.6	20.2	21.7	23.3	24.8	42
43	3.1	4.7	6.3	7.9	9.5	11.1	12.7	14.3	15.9	17.5	19	20.7	22.2	23.8	25.4	43
44	3.2	4.8	6.5	8.1	9.7	11.3	13	14.6	16.2	17.9	19.5	21.1	23.7	24.4	26	44
45	3.3	4.9	6.7	8.3	9.9	11.6	13.3	15	16.6	18.4	19.9	21.6	23.2	24.9	26.6	45
46	3.4	5.1	6.8	8.5	10.2	11.9	13.6	15.3	17	18.7	20.4	22.1	23.8	25.5	27.2	46
47	3.4	5.2	7	8.7	10.4	12.1	13.9	15.6	17.4	19.1	20.8	22.6	24.3	26	27.8	47
48	3.5	5.3	7.1	8.9	10.6	12.4	14.2	16	17.8	19.5	21.3	23.1	24.8	26.6	28.4	48
49	3.5	5.4	7.3	9.1	10.8	12.7	14.5	16.3	18.1	19.9	21.7	23.6	25.3	27.1	29.2	49
50	3.6	5.5	7.4	9.2	11.1	12.9	14.8	16.6	18.4	20.3	22.1	24	25.8	27.7	29.5	50
51	3.7	5.6	7.6	9.3	11.3	13.1	15.1	17	18.8	20.7	22.5	24.5	26.3	28.2	30.1	51
52	3.8	5.7	7.7	9.6	11.5	13.4	15.4	17.3	19.2	21.1	23	25	26.9	28.8	30.7	52
53	3.9	5.9	7.9	9.8	11.7	13.7	15.7	17.6	19.6	21.5	23.5	25.5	27.4	29.4	31.3	53
54	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	54
55	4.1	6.1	8.2	10.2	12.2	14.3	16.3	18.3	20.4	22.4	24.4	26.5	28.5	30.5	32.6	55
56	4.1	6.2	8.3	10.4	12.4	14.5	16.6	18.6	20.7	22.8	24.9	27	29.1	31.1	33.2	56
57	4.2	6.3	8.5	10.6	12.6	14.8	16.9	19	21.1	23.2	25.3	27.5	29.6	31.6	33.8	57
58	4.3	6.5	8.6	10.7	12.8	15	17.1	19.3	21.5	23.6	25.8	27.9	30.1	32.2	34.4	58
59	4.3	6.5	8.8	10.9	13	15.3	17.4	19.6	21.9	24	26.2	28.4	30.6	32.7	35	59
60	4.4	6.6	8.9	11.1	13.3	15.5	17.7	20	22.2	24.4	26.6	28.8	31.1	33.3	35.5	60
61	4.5	6.7	9.1	11.3	13.5	15.8	18	20.3	22.6	24.8	27	29.4	31.5	33.8	36.1	61
62	4.6	6.9	9.2	11.5	13.7	16	18.3	20.6	22.9	25.2	27.5	29.8	32.1	34.4	36.7	62
63	4.6	7	9.3	11.6	13.9	16.3	18.6	21	23.3	25.7	27.9	30.3	32.6	35	37.3	63
64	4.7	7.1	9.5	11.8	14.2	16.5	18.9	21.3	23.6	26	28.3	30.8	33.1	35.5	37.8	64
65	4.8	7.2	9.6	12	14.4	16.8	19.2	21.6	24	26.5	28.9	31.3	33.7	36.1	38.5	65

NUMBER OF CUBIC YARDS IN AN EXCAVATION OR CELLAR TO EACH FOOT IN DEPTH—(*Continued*).
FROM 17×36 TO 30×65.

Length in Feet.	Width in Feet.														Length in Feet.
	17	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	
36	21.6	24	25.3	26.6	28	29.3	30.6	32	33.3	34.6	36	37.3	38.6	40	**36**
37	22.2	24.6	26	27.3	28.7	30.1	31.5	32.8	34.2	35.5	37	38.3	39.7	41.1	**37**
38	23.9	25.3	26.7	28.1	29.5	30.9	32.3	33.7	35.1	36.5	38	39.4	40.8	42.2	**38**
39	24.5	26	27.4	28.9	30.3	31.8	33.1	34.6	36	37.5	39	40.4	41.9	43.3	**39**
40	25.1	26.6	28.1	29.6	31.1	32.6	34	35.5	37	38.5	40	41.5	42.9	44.4	**40**
41	25.7	27.3	28.8	30.3	31.8	33.4	34.8	36.4	37.9	39.4	41	42.5	44	45.5	**41**
42	26.4	28	29.5	31.1	32.6	34.2	35.7	37.3	38.8	40.4	42	43.5	45	46.6	**42**
43	27	28.6	30.2	31.9	33.4	35	36.5	38.2	39.8	41.4	43	44.6	46.1	47.7	**43**
44	27.7	29.3	30.9	32.6	34.2	35.8	37.4	39.1	40.7	42.3	44	45.6	47.2	48.8	**44**
45	28.3	30	31.6	33.3	35	36.6	38.2	40	41.6	43.3	45	46.6	48.3	49.9	**45**
46	28.9	30.6	32.3	34	35.7	37.4	39.1	40.8	42.5	44.3	46	47.7	49.4	51.1	**46**
47	29.5	31.3	33	34.8	36.5	38.3	39.9	41.7	43.4	45.2	47	48.7	50.4	52.2	**47**
48	30.2	32	33.8	35.5	37.3	39.1	40.8	42.6	44.3	46.1	48	49.7	51.5	53.3	**48**
49	30.8	32.6	34.5	36.3	38.1	39.9	41.6	43.5	45.3	47.1	49	50.8	52.6	54.4	**49**
50	31.4	33.3	35.1	37	38.8	40.7	42.5	44.4	46.2	48.1	50	51.8	53.7	55.5	**50**
51	32	34	35.8	37.3	39.6	41.5	43.3	45.3	47.1	49.1	51	52.8	54.7	56.6	**51**
52	32.7	34.6	36.5	38.5	40.4	42.3	44.2	46.2	48	50	52	53.9	55.8	57.7	**52**
53	33.3	35.3	37.2	39.3	41.2	43.1	45.1	47.1	49	51	53	54.9	56.9	59.9	**53**
54	34	36	38	40	42	44	46	48	50	52	54	56	58	60	**54**
55	34.6	36.6	38.7	40.7	42.8	44.8	46.8	48.9	50.9	52.9	55	57	59	61.1	**55**
56	35.2	37.3	39.4	41.4	43.5	45.6	47.6	49.7	51.8	53.9	56	58	60.1	62.2	**56**
57	35.8	38	40.1	42.1	44.3	46.4	48.4	50.6	52.7	54.8	57	59.1	61.1	63.3	**57**
58	36.5	38.6	40.8	42.9	45.1	47.2	49.3	51.5	53.7	55.8	58	60.1	62.2	64.4	**58**
59	37.1	39.3	41.5	43.6	45.9	48	50.2	52.4	54.6	56.8	59	61.1	63.3	65.5	**59**
60	37.7	40	42.2	44.4	46.6	48.8	51	53.3	55.5	57.7	60	62.2	64.4	66.6	**60**
61	38.3	40.6	42.9	45.1	47.4	49.6	51.9	54.2	56.5	58.7	61	63.2	65.5	67.7	**61**
62	39	41.3	43.6	45.9	48.2	50.5	52.8	55.1	57.4	59.7	62	64.2	66.6	68.8	**62**
63	39.6	42	44.2	46.6	49	51.3	53.6	56	58.3	60.6	63	65.3	67.6	69.9	**63**
64	40.2	42.6	44.9	47.4	49.7	52.1	54.4	56.8	59.2	61.6	64	66.3	68.7	71.1	**64**
65	40.9	43.3	45.7	48.1	50.5	52.9	55.3	57.7	60.1	62.5	65	67.4	69.9	72.2	**65**

NUMBER OF CUBIC YARDS IN AN EXCAVATION OR CELLAR TO EACH FOOT IN DEPTH—(*Continued*).
FROM 31×36 TO 40×65.

Length in Feet.	Width in Feet.										Length in Feet.
	31	32	33	34	35	36	37	38	39	40	
36	41.3	42.6	44	45.3	46.7	48	49.3	50.7	52	53.4	36
37	42.4	43.8	45.2	46.9	48	49.3	50.7	52.1	53.5	54.9	37
38	43.6	45	46.4	47.9	49.3	50.7	52.1	53.5	54.9	56.3	38
39	44.8	46.2	47.6	49.1	50.7	52	53.5	54.9	56.3	57.8	39
40	46	47.4	48.8	50.3	51.8	53.4	54.9	56.3	57.8	59.2	40
41	47.1	48.5	50	51.5	54.1	54.7	56.2	57.7	59.2	60.7	41
42	48.2	49.7	51.3	52.8	54.4	56	57.6	59.1	60.6	62.2	42
43	49.3	50.9	52.5	54.1	55.7	57.3	59	60.5	62.1	63.7	43
44	50.5	52.1	53.7	55.4	57	58.7	60.4	61.9	63.5	65.2	44
45	51.7	53.3	54.9	56.6	58.3	60	61.7	63.3	64.9	66.6	45
46	52.8	54.5	56.2	57.9	59.6	61.3	63.1	64.7	66.4	68.1	46
47	53.9	55.6	57.4	59.1	60.9	62.7	64.5	66.1	67.8	69.6	47
48	55.1	56.8	58.6	60.4	62.2	64	65.8	67.5	69.3	71.1	48
49	56.3	57.7	59.8	61.6	63.5	65.3	67.2	68.9	70.8	72.6	49
50	57.4	59.2	61.1	62.9	64.8	66.7	68.6	70.3	72.2	74	50
51	58.6	60.4	62.3	64.2	66.1	68	69.8	71.7	73.6	75.5	51
52	59.7	61.6	63.5	65.5	67.4	69.3	71.2	73.1	75	77	52
53	60.9	62.8	64.7	66.7	68.7	70.7	72.6	74.5	76.5	78.5	53
54	62	64	66	68	70	72	74	76	78	80	54
55	63.2	65.2	67.2	69.2	71.3	73.3	75.3	77.4	79.4	81.5	55
56	64.3	66.3	68.4	70.5	72.6	74.7	76.7	78.8	80.8	82.9	56
57	65.5	67.5	69.6	71.7	73.9	76	78.1	80.2	82.3	84.4	57
58	66.6	68.7	70.9	73	75.2	77.3	79.4	81.6	83.7	85.9	58
59	67.7	69.9	72.1	74.2	76.5	78.7	80.9	83	85.2	87.4	59
60	68.8	71	73.3	75.5	77.7	80	82.2	84.4	86.6	88.8	60
61	70	72.3	74.7	76.8	79	81.3	83.5	85.8	88	90.3	61
62	71.1	73.3	75.7	78.1	81.4	82.7	84.9	87.2	89.5	91.8	62
63	72.3	74.7	77.1	79.3	81.7	84	86.3	88.6	90.9	93.3	63
64	73.5	75.9	78.2	80.6	82.9	85.3	87.6	90	92.4	94.8	64
65	74.7	76.2	79.7	81.9	84.2	86.7	89	91.4	93.8	96.3	65

NUMBER OF CUBIC YARDS IN AN EXCAVATION OR CELLAR TO EACH FOOT IN DEPTH—(*Continued*).
FROM 41×36 TO 50×65.

Length in Feet.	Width in Feet.										Length in Feet.
	41	42	43	44	45	46	47	48	49	50	
36	54.7	56	57.3	58.7	60	61.3	62.7	64	65.3	66.7	36
37	56.2	57.6	59	60.4	61.7	63.1	64.5	65.8	67.2	68.6	37
38	57.7	59.1	60.5	61.9	63.3	64.7	66.1	67.5	68.9	70.3	38
39	59.2	60.6	62.1	63.5	64.9	66.4	67.8	69.3	70.8	72.2	39
40	60.7	62.2	63.7	65.2	66.6	68.1	69.6	71.1	72.6	74	40
41	61.5	63.7	65.3	66.8	68.3	69.8	71.3	72.8	74.3	75.8	41
42	63.7	65.3	66.9	68.5	70	71.5	73.1	74.6	76.1	77.7	42
43	65.3	66.9	68.5	70.1	71.6	73.2	74.8	76.4	78	79.6	43
44	66.8	68.5	70.1	71.7	73.3	74.9	76.5	78.2	79.9	81.5	44
45	68.3	70	71.6	73.3	75.7	76.6	78.2	79.9	81.6	83.3	45
46	69.8	71.5	73.2	74.9	76.6	78.3	80	81.7	83.4	85.1	46
47	71.3	73.1	74.8	76.5	78.2	80	81.8	83.5	85.2	86.9	47
48	72.8	74.6	76.4	78.2	79.9	81.7	83.5	85.3	87	88.8	48
49	74.3	76.1	78	79.9	81.6	83.4	85.2	87	88.9	90.4	49
50	75.8	77.7	79.6	81.5	83.3	85.1	86.9	88.8	90.4	92.5	50
51	77.4	79.3	81.1	83.1	84.9	86.8	88.7	90.5	92.3	94.4	51
52	78.9	80.9	82.6	84.7	86.6	88.6	90.4	92.2	94.2	96.3	52
53	80.5	82.5	84.3	86.3	88.3	90.3	92.2	94.1	96.1	98.1	53
54	82	84	86	88	90	92	94	96	98	100	54
55	83.5	85.6	87.6	89.6	91.7	93.7	95.8	97.8	99.8	101.8	55
56	85	87.1	89.2	91.2	93.3	95.4	97.5	99.5	101.6	103.7	56
57	86.5	88.6	90.7	92.8	95	97.1	99.2	101.3	103.4	105.5	57
58	87.9	90	92.2	94.5	96.7	98.8	101	103.1	105.3	107.4	58
59	89.5	91.6	98.8	96.1	98.3	100.2	102.7	104.8	106.6	109.2	59
60	91	93.3	95.5	97.7	99.9	102.2	104.4	106.6	108.8	111.1	60
61	92.6	94.9	97.1	99.3	101.6	103.9	106.1	108.4	110.6	112.9	61
62	94.1	96.4	98.7	101	103.3	105.6	107.9	110.2	112.5	114.8	62
63	95.6	98	100.2	102.5	104.9	107.3	109.6	111.9	114.3	116.6	63
64	97.1	99.5	101.7	104	106.5	109	111.3	113.7	116.1	118.5	64
65	98.7	101.1	103.5	105.9	108.3	110.7	112.1	115.5	117.9	120.3	65

Tin Roofing. — Tin for flat roofs is usually put on with the ordinary flat lock joint, the sheets of tin being nailed under the lock. After the sheets are nailed and hooked together the hook joints are beaten down with a wooden mallet and then soldered.

When it is desired to make some allowance for contraction and expansion the sheets should be fastened with tin clips nailed to the roof as shown by Fig. 73; in this way there are no nails through the sheets of tin, but they are held in place by the clips. Fig. 74 shows a section of the joint.

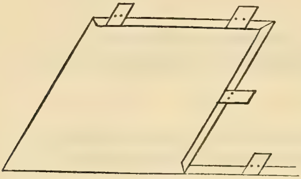


Fig. 73.

Standing seam roofs are also fastened with clips nailed to the sheathing and turned down in the standing seam. Fig. 75, 1, 2, 3, shows a standing seam roof in the different stages of construction.

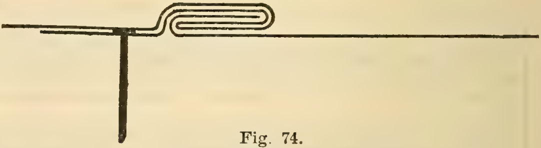


Fig. 74.

Fig. 75, at 5, shows the joint turned down in a flat lock joint.

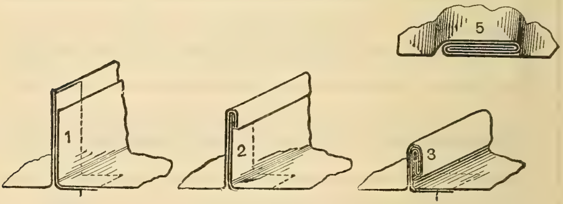


Fig. 75.

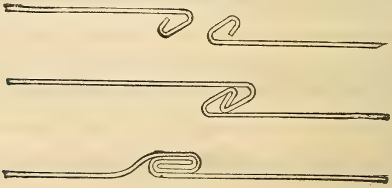


Fig. 76.

In standing seam roofs or any roof where the tin is laid in long lengths the cross-joints should be double-locked; this is

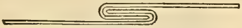


Fig. 77.

shown in Fig. 76, while Fig. 77 shows the ordinary single lock.

Tin roofs are sometimes put on in lengths running with the slope of the roof, the strips of tin being turned up and laid between strips of wood, as shown by Fig. 78. This method is used to make an allowance for expansion and contraction.

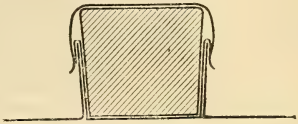


Fig. 78.

Figs. 79 and 80 show another method of putting a cap over the wooden strip; this makes a very good roof and all the tin is held in place by the

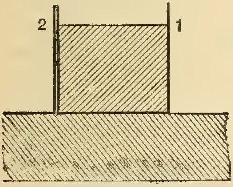


Fig. 79.

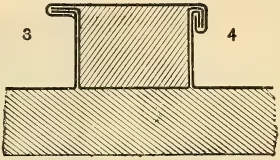


Fig. 80.

clips under the wooden strips and the lock joint. The different stages of construction of the joint are shown in the two figures.

Fig. 81 shows a method used for zinc and copper, while Fig. 82 shows how the cross-joints should be made at the ends of the sheet of metal.

A rise or step should be made in the roof and the two sheets of metal turned and locked as shown in Fig. 82. In working zinc care must be exercised in making the bends and angles, for if they are made too sharp the metal is liable to crack.

Wherever any metal roof covering finishes at a wall or any place where flashing is necessary the roof metal should be turned up 8 or 10 inches and securely fastened; then this metal should be counter-flashed and the flashing let into the joint of the wall at least 2 inches and well cemented. This is one part of the work that the tinner should pay particular attention to, so as to get everything water-tight.

In all metal roofing the main points are to get the roof watertight and to make provision for expansion and contraction.

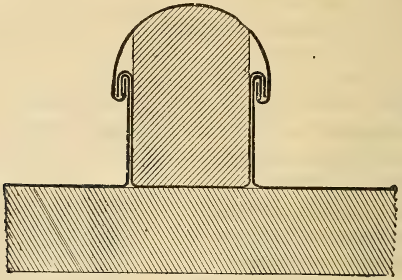


Fig. 81.

PAINTING. — As soon as the roofing is in place and the joints all soldered, it should then be painted. Before painting the roof it should be gone over and all grease, oil, resin, etc., removed.

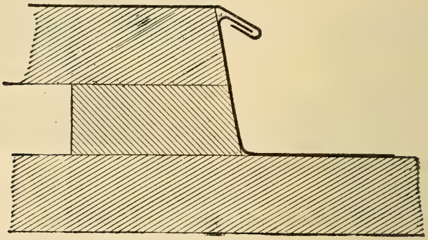


Fig. 82.

In no case should an acid flux for soldering be used on a tin roof; and in case an acid flux or a flux of chloride of zinc has been used, the places soldered should be washed thoroughly with a solution of common soda to prevent rusting. It must be an alkali wash to be effective, or a wash of benzine is good for removing grease, etc. Red lead is usually used for painting tin work; it should be composed of 15 pounds of red lead to 1 gallon of raw linseed oil.

Tin should be painted as soon as possible after being put in place, and if any rust shows it should be removed. If the tin is greasy, as it sometimes is when just from the factory, it should be washed all over with a wash of 1 pound of sal-soda in 6 quarts of water. Let the tin stand about half a day after applying this

wash, and then wash with clean water to remove any traces of the soda, then paint as soon as dry.

To put on a Good Roof. — Roofs less than one-fifth pitch should be made with flat seams well locked together. The sheets of tin should be of the small size, 14 × 20, as the small sheets cause more seams and make a stiff roof which prevents buckling. Ordinarily nails are driven through the edge of the sheet under the lock, but in good work the sheets should be fastened with tin clips or cleats nailed to the roof. This leaves the tin of the roof free to expand and contract. Nails or cleats should be used about every six or seven inches. In soldering the seams great care should be used and time taken to "sweat" the solder well up into the lock of the seam.

When working on a tin roof always wear rubber-soled shoes, such as tennis shoes; the nails in ordinary shoes have been the cause of many a leak in an otherwise perfect roof. The nail either punches a hole or scrapes off the tin coating so the iron is exposed, and rust does the rest. A bad habit some workmen have is sliding down a valley, or, if the roof is a fairly steep one, they will slide down the tin, the nails in their shoes scoring through the tin coating and exposing the iron plate. The author had to reject a tin roof which was perfect when put on but which was let stand several weeks without painting, and on which workmen were walking and sliding as mentioned until in some places the tin coating was all worn off the plate.

A standing seam should not be used on a roof of less than one-fifth pitch, while on a steeper roof it may be tight for rain; in the winter the snow and ice will cause the water to back up under the seam.

As previously mentioned, acid should never be used for a flux in soldering on a tin roof; the acid works up into the lock, and coming in contact with the bare iron at the edge of the sheet will cause rusting. Resin is the only flux that should be used on a roof, and all surplus resin cleaned off before painting.

Tin should always be painted on the under side to prevent rusting; and a layer of good rosin-sized paper is of great benefit, as it absorbs the moisture from the rooms below, and acts as a cushion to the tin.

On fireproof or concrete buildings the tin is often fastened direct to the roof slab; in such cases the tin should be given two coats of paint on the under side before laying.

The wood sheathing under a tin roof should always be surfaced to an even thickness, and if matched sheathing is used it makes a better roof. If there are any loose knots or knot holes they should be covered with pieces of heavy tin before putting on the roof.

INSTRUCTIONS FOR PUTTING ON A TIN ROOF. — The following instructions for putting on a tin roof are taken by permission from an article by W. B. Goddard, in "The Metal Worker," May 12, 1906.

"Taking it for granted that the roof has been properly constructed, with a good pitch, covered with good, well dried sheathing boards, the gutters and valleys broad and generous, with a sharp pitch, so as to carry off the water just as rapidly as it falls, we come to the roofer's part of the work. Cover the roof first of all with a good waterproof paper, for paper of the right kind is just as good for a tin roof as lining is for a carpet. When I speak of waterproof paper I do not mean that it is put there to hide any leaks that may develop, for that would be poor workmanship. A leak should be stopped as soon as discovered, and nothing put in the way of its discovery, but the paper is put under the tin to protect the tin from gases and dampness from below or anything in the sheathing. A good waterproof paper will absorb no dampness, but will dry at once, while rosin-sized or other soft nonwaterproof papers absorb and hold dampness, and are therefore injurious to the tin and should never be used. If you cannot use a waterproof paper, use none at all. Better put your tin right on the plain boards.

Now lay your tin either standing or flat seams, using IC for the body of the roof and IX for the gutters. Sheets 28 × 20-inch size should always be used when it can be in gutter work, so as to have as few seams as possible. The gutter gets the hardest use and should be the most carefully laid. All tin on roofs should be fastened down with cleats. A nail should never be driven through the body of the tin. When laid with cleats and properly soldered, the finished product is practically a solid sheet of tin covering the whole roof as securely as a blanket covers a bed. The expansion and contraction is all taken care of by the cleats, and if the cleats are properly applied the roof will never rattle.

NAILS SHOULD NEVER BE DRIVEN THROUGH SHEETS. — If laid with nails driven through the sheets, the sheathing boards must be depended upon entirely for taking care of the expansion

and contraction, and the nail holes will invite leaks. When a roof is put on with single sheets of 14×20-inch tin, with two nails on the cross seam and three on the long seam, the sheet is fastened firmly to the boards, and if the boards shrink something has to give, and it is usually the seam. Besides, after turning the seam down over the nail head there is only from $\frac{1}{16}$ to $\frac{1}{8}$ inch from edge of nail head to outside of seam, and it is impossible to make the solder flow over and under that nail head to make a strong seam. The solder flows all around the nail head, but never over it, and in consequence there are five weak spots in every 14×20 sheet. A year or so ago I inspected a roof put on in this way, which leaked like a sieve. The roof, to all appearances, was well laid, liberally soldered, but leaked in every seam. The roofer, a man of experience and standing in his town, claimed that his solder had run in and completely covered the nail, making a tight seam. To prove to him his error I had him cut open a cross and long seam, and then he saw the mark of every nail; the solder had run all around the nail, not under or over it, and less than $\frac{1}{16}$ inch between edge of tin and nail head. The roofer looked at me and simply could say nothing. He afterward asked what he ought to have done, and I told him he should have fastened the tin on the roof with cleats. He said he had never in all his twenty-five years of experience heard of putting a flat seam roof on with cleats, although he learned his trade in one of the best shops in New York City. That roof is soldered about every month and still leaks. Care should be taken in soldering all seams. Only rosin should be used and a liberal quantity of solder. The seams should be well soaked and the iron only hot enough to fuse the solder.

Finishing and Painting. — The roof having been laid, it is now ready for the finishing work. Do not let the roof lay a day after it is done before it is painted. Never under any circumstances let it rust. After having carefully rubbed off and removed all the rosin on the seams commence the last and by no means the least important part of the work. The paint used should be of the best quality of Prince's metallic or Venetian red, although the writer prefers the metallic. It should be bought ground in oil and thinned with pure linseed oil, adding a little litharge as a drier; this last makes it set hard and grips the metal, so that a few weeks after application it would be hard to scrape off. Keep the paint well stirred up and apply with a

hand brush, using just enough paint to cover, and rubbing it well in, just as when painting wood. There is just as much art in painting a tin roof as there is in painting a wooden house. Do not provide a whitewash brush, with a 6-foot handle, so that the workman can stand up and not bend his back, and paint the roof the same as he would whitewash the side of a barn or fence, or put on a coat of coal tar, but have him get right down to good hard work, always bearing in mind " that what is worth doing at all is worth doing well." A roof painted this way is worth a half dozen painted as they are every day in the manner I have described — viz., as " Sambo whitewashes your cellar." The saving in the paint properly applied almost makes up for the extra labor.

The roof is now finished and should be a job to be proud of. The roof should be painted again in a month or six weeks. If the roof is laid in the spring it should have its third coat in the fall, or if laid in the fall, the next spring, after which it should be painted every three years in the fall, as that is the best time, because the winter months are the hardest on a tin roof. The writer submits a copy of specifications gotten up by him for a New York architect. These have the indorsement of some of the best roofers, and have been asked for by many other architects interested in the best methods of applying tin roofs.

Specification for Tin Roofing. — All of the tin used for roofing all parts of this building shall be iron sheets, which shall be stamped with the brand and thickness on each sheet.

All tin used for standing seam roofing shall be IC thickness, 14 × 20 inches, applied the 14-inch way, forming seams with a double lock. All tin for standing seam roofing shall be put together in rolls with the cross seams formed and soldered, same as specified for flat seam roofing. Use 1 × 28 × 20 for gutters.

All standing seam roofing shall be fastened to roof with 2-inch wide tin cleats, spaced 8 inches apart, with cleats locked into seams, and fastening each cleat with two 1-inch barbed wire nails.

All tin used for flat roofing shall be IC thickness, 14 × 20-inch size, and for gutters tin shall be IX thickness, 28 × 20-inch size, using flat seams, with $\frac{3}{8}$-inch lock. Flat seam roofing to be made up and soldered in the shop in long lengths, which must be painted on under side with one coat of paint and allowed to dry before applying to the roof. All flat seam roofing shall be fastened to roof with 2-inch wide flat tin cleats, spaced 8 inches

apart, with cleat locked into seams, and each cleat nailed to roof with two 1-inch barbed wire nails. When the rolls of tin are laid on roof the edges shall be turned up $\frac{1}{2}$ inch at right angles to roof, when the cleats shall be installed. Then another course shall be applied with $\frac{1}{2}$-inch upturned edge, and then the adjoining edges shall be locked together, and the seam so formed shall be flattened to a rounded edge and well soldered and soaked in.

All valleys shall be formed with flat seam roofing, using 14×20-inch sheets laid in the narrow way, with cross seams put together and well soldered, same as specified for flat roofing.

All flat seams throughout the roof, including such other parts as may need soldering to make perfectly water tight, shall be soldered with best grade of guaranteed half and half solder (half tin and half lead), using nothing but rosin as a flux. Not less than 2 pounds of solder shall be used per square on standing seam roofing, and not less than 8 pounds per square on flat seam roofing, all to be well sweated into the joints.

All rosin used in soldering must be carefully cleaned from all surfaces before any paint is applied to the tin.

All tin shall be painted one coat on concealed or under sides, as heretofore specified, and two coats on all exposed surfaces; the first coat shall be given four weeks to dry before the second coat is applied. All paint shall be applied with hand brushes and well rubbed in. Litharge only shall be used as a drier. No patent drier or turpentine to be used. The first coat on upper surface shall be applied as soon as laid, and tin must not be permitted to rust before painting.

To sum up, the requisites for a good tin roof are:

1. Plate made on a good, lasting base, heavily coated; one that will stand just as well as those of fifty years ago.

2. Careful preparation in the shop, using all the care possible before sending the plate to the roof.

3. The best workmanship in laying; always using cleats. Never nail through the body of the sheet. Liberal use of solder, avoiding the use of too hot irons. Walk on roof as little as possible, and never with shoes in which the nails will do damage. Felt-soled shoes or rubbers should be worn.

4. The utmost care in finishing and painting.

Roofing Specifications. — The following specifications for tin roofing were prepared and issued by The National Association of Master Sheet Metal Workers.

All tin used for roofing all parts of this building shall be X or Y or Z brand. No substitute for the above grade or brand will be allowed, and the same is to be purchased from the jobber or manufacturer in boxes.

The sheets used for standing seam roofing shall be made up into long lengths in the shop. The cross seams shall be locked together and well soaked with solder. One coat of paint shall be applied to the under side before laying.

If the sheets are laid singly the size shall be 14 × 20, painted one coat on the under side before laying. The sheets shall be fastened to the sheathing boards by cleats, using three to each sheet, two on the long side, one on the short side. Two 1-inch barbed wire nails to each cleat.

All seams, whether locked or standing, shall be made according to the accompanying diagrams. No nails shall be driven through the sheets.

All tin used for standing seam roofing shall be applied the narrow way, fastened to the roof with cleats spaced 8 inches apart. Cleats locked into the seam and fastened with two 1-inch barbed wire nails to each cleat.

All flat seam roofing shall be applied the narrow way, fastened to the roof with cleats spaced 8 inches apart. Cleats locked into the seam and fastened to the roof with two 1-inch barbed wire nails to each cleat.

The edges for standing seam roofing shall be turned up not less than $1\frac{1}{4}$ inches at right angles to the roof, when the cleats shall be installed. Then another course with $1\frac{1}{2}$-inch edge turned up. Adjoined edges shall be locked together, and the seams so formed shall be flattened to a rounded edge.

The valleys shall be formed with flat seams, using sheets the narrow way.

All solder used on this roof shall be of the best grade and guaranteed one-half and one-half solder (one-half tin and one-half lead), using nothing but rosin as a flux. Solder to be well sweated into all seams and joints.

Surface of tin to be carefully cleaned from all rosin before paint is applied.

All tin shall be painted one coat on the under side and two coats on all exposed surfaces. The first coat shall be applied to the upper side immediately after laying with a hand brush, well rubbed in. The second coat shall be applied in a similar manner

in not less than two weeks after the first coat has been put on. All paint used shall be of the best metallic brown mixed with pure linseed oil, japan only as a drier. No patent drier or turpentine shall be used.

No unnecessary walking over the roof or using the same for storage of other material shall be allowed. When necessary to walk over the roof, care must be exercised not to break the coating of the tin. Particular care and attention must be given to the laying of the gutters, so that, when finished, there shall be sufficient pitch to prevent any water standing therein.

No deviation from these specifications shall be made. They must be carried out in every particular. A first class roof only will be accepted.

When paper is specified the same is to be of the waterproof kind.

Explanation of Diagrams in Fig. 84. — Flat seam roofing when the sheets are laid in strips or one at a time.

AA shows sheets with edge turned ready for locking.

B, sheet or strip laid with cleat locked over turned up edge. The cleat is $1\frac{1}{2}$ inches wide. Two 1-inch barbed wire nails are

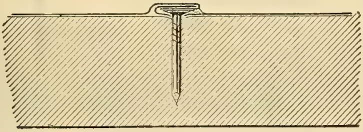


Fig. 83. Weak point of Seams nailed through Sheets.

driven through the cleat into the roof sheathing. These nails must be driven close as possible to the edge of the sheet, otherwise the cleat will have too much play. Cleats must be spaced 8 inches apart.

C, seam or joint completed by locking the two edges A and B together and soldering. The cleat is not shown.

Standing Seam Roofing. — DD, edges of sheets or strips turned up at right angles to the roof not less than $1\frac{1}{4}$ and $1\frac{1}{2}$ inches respectively.

E, sheet or strip laid with cleat locked over upturned edge. Cleats spaced 8 inches apart and fastened with two 1-inch barbed wire nails.

F, opposite sheet or strip laid in place.

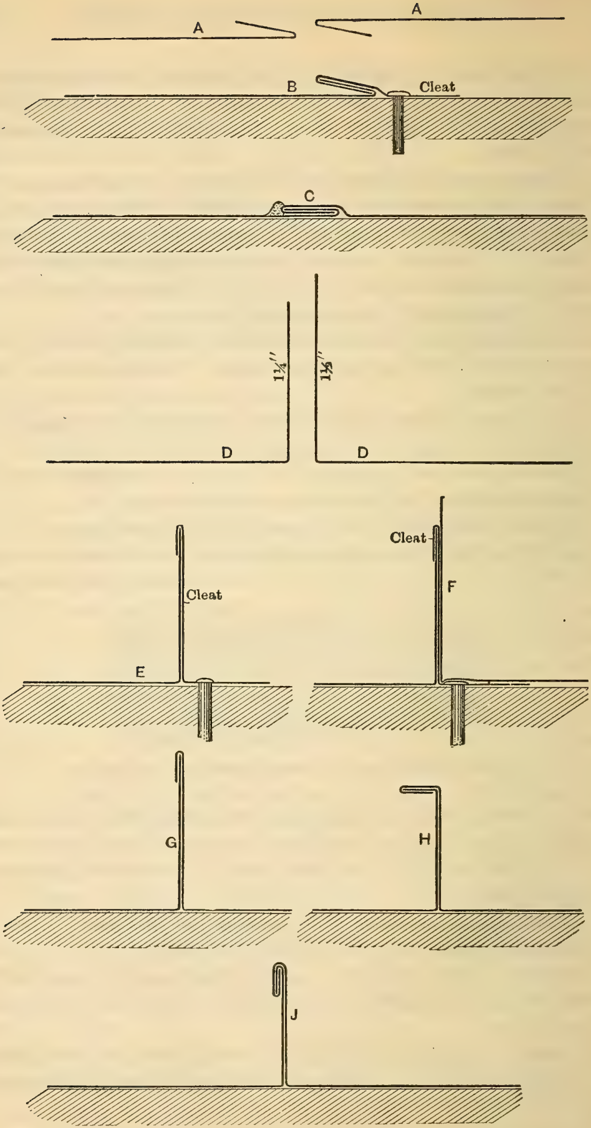


Fig. 84. Method of making Flat and Standing Seams.

G, edges of the two sheets or strips locked together. Cleat not shown.

H, second operation of locking the edges.

J, the standing seam complete.

Diagrams for laying flat and standing seam roofing as explained in the foregoing specifications.

Practical Hints for Tinners. — Look over the roof before starting to lay the tin, and if there is anything wrong with the slope of the gutters or the quality of the sheathing-boards, etc., report it to the architect before starting the work. Trouble with the roof arising from these causes may later be blamed on you.

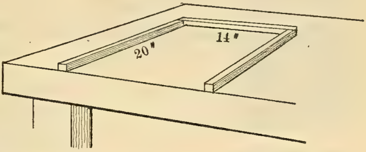


Fig. 85. Frame for painting Sheets of Tin.

See that the downspouts and gutters are designed to be of ample capacity for heavy rains.

Keep a record of the roofs you put on and see that they are kept painted from time to time, and the gutters and valleys cleaned out.

Move the fire-pot about from time to time to prevent continuous walking to and fro in one place.

Experience has shown that there is galvanic action between tin and copper, or galvanized iron and copper. If possible, avoid joining these metals together.

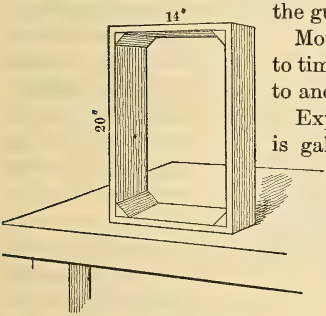


Fig. 86. Guide for protecting Edges.

Frame for Painting Sheets of Tin. — A handy frame and guide for painting single sheets of tin to within a short distance of the edge can be made as shown by Figs. 85 and 86. The sheet is laid in the frame, and the guide — a shallow box — made as shown by Fig. 86, is placed in the frame over the tin to be painted; thus by painting inside the box the sheet of tin is painted over the whole surface except a margin covered by the box frame, as shown by Fig. 87.

To scribe off Tin Projections for cutting. — To line off

the tin projection of a roof or gutter cap so the tin will have the same projection at all points, take a block of wood as shown at *A*, Fig. 88, and nail on a strip of tin as *B*; let the block rest against the cap as shown and turn the end of the strip of tin down to scratch at the desired point to cut the tin.

Cut the end of the strip of tin to form a point so it will scratch the tin and run the block along the cap, keeping the strip of tin pressed down so it will scribe the tin for cutting.

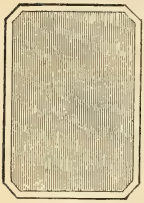


Fig. 87. The painted Sheet.

Expansion Joint in Copper Gutter. — Fig. 89 shows how an expansion joint can be made in a copper gutter to take care of the lenial expansion and contraction of the gutter.

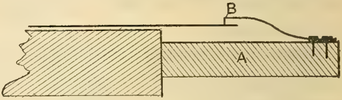


Fig. 88. Scribbing Block.

The joint should be made at the highest point of the gutter, so the water will run away from the joint in both directions as indicated by the arrows. The joint is made by locking and soldering an end in each section of the gutter and butting the two ends together as shown. The ends are then covered with a cap as shown at *A* and *B*.

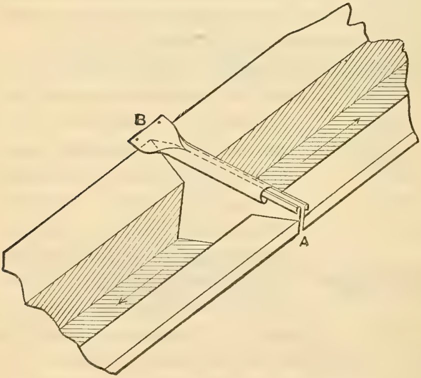


Fig. 89. Expansion Joint in Gutter.

The ends should extend above the cap of the cornice, so the water would run over the cornice cap before running over the joint.

On the top edge of the ends turn a lock or hook as shown, then make a cap with a lock turned on each side so it can be slipped

over the ends and engage with the locks on the ends of the gutter. At the top as at *B* this cap must be flared out to lay flat on the roof as shown and fastened. There must be space enough left between the two sections of gutter to allow for all expansion as shown at *A*.

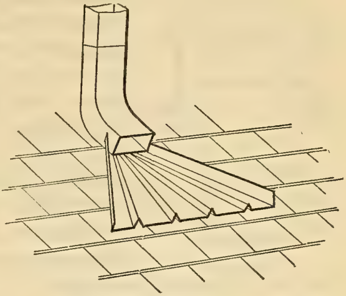


Fig. 90. Water Spreader.

WATER SPREADER. — When a downspout discharges onto a roof as shown by Fig. 90, it is advisable to make a flaring corrugated pan as shown and place under the shoe of the spout, so that the water will be spread over the roof and not have a large quantity of water running down the roof at one place.

GUIDE FOR NOTCHING CORNERS OF TIN SHEETS.— A frame or guide for notching the corners of tin sheets can be made with a piece of stiff sheet metal bent as shown by Fig. 91.

ROSIN SPREADER. — To spread the powdered rosin along the joint

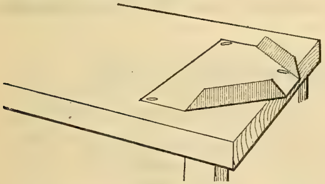


Fig. 91. Guide for notching Corners of Tin Sheets.

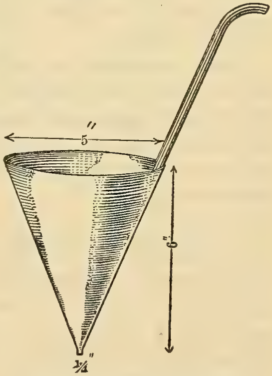


Fig. 92. Rosin Spreader.

to be soldered a tool such as shown by Fig. 92 can be used to advantage. A piece of tin is turned to the shape of a funnel making the hole at the point just large enough for the rosin to run through.

VENTILATORS. — There are a number of various kinds and styles of ventilators on the market, the majority of which are sold under patent. Nearly all of the various ventilators give good satisfaction, but there is one, known as The Emerson Ventilator, shown by Fig. 93, and which is just as efficient as any on the market, and can be made by any one, as the patent on it has expired. This ventilator gives good satisfaction either for ventilation purposes or for smoke, as its shape insures an upward draft no matter which way the wind is blowing.

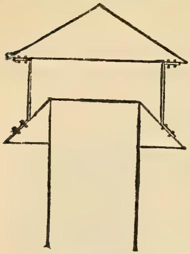


Fig. 93.

TIN-PLATE. — Tin-plate is sheet iron, or steel coated with tin. Terne-plate is a plate of sheet iron coated with tin and lead and is inferior in quality to the tin-plate. The best plates are those known to be made by the " charcoal " or " old " process.

Plates coated with tin are known as " bright tin," while those coated with a mixture of tin and lead are known as " terne " or " dull " plates.

Plates are made in two weights, IC and IX. The IC is No. 30 gauge and weighs five pounds to the square foot; the IX is No. 28 gauge and weighs .625 pounds per foot.

Imperfect sheets are called " wasters," and the letter W on a box after the IC or IX indicates that the box contains imperfect sheets.

SOLDERS TO USE FOR DIFFERENT METALS.

Material to be Soldered.	Solder to Use.
Tin	Soft, coarse or fine.
Lead	Soft, coarse.
Brass, copper, iron, and zinc	Soft, coarse.
Pewter	Pewterers' or fusible.
Brass	Spelter, soft.
Copper and iron	Spelter, soft or hard.

Solder may be tested by melting, when, if a great many bright spots appear floating on the top, it must be considered too soft or fine, while if the spots are totally absent, it contains too much lead. Tin spots about three-eighths of an inch in diameter indicate good solder.

Fluxes are used to aid in the fusion of solder and to clean the surface of the metals to be soldered. Those commonly used and the metals to which they are applied are as follows:

Flux.	Metals to be Joined.
Rosin	Lead, tin, or tinned metals.
Tallow	Copper, iron, and lead.
Sal ammoniac	Dirty zinc, copper, and brass.
Muriatic or hydrochloric acid	Clean zinc, copper, tin, or tinned metals.
Chloride of zinc	Lead, zinc, tin tubes, and tinned metals.
Borax	Iron, steel, copper, brass, gold, and platinum.

COMPOSITION AND FUSING-POINTS OF SOLDER.

Kind.	Hard.			Soft.			Fusing-point.
	Zinc.	Copper.	Silver.	Tin.	Lead.	Bismuth.	
Spelter, hardest	1						700°
" hard	2	3					550°
" soft	1	1					
" fine	2	2	$\frac{1}{4}$				
Silver, hard		1	4				
" medium		1	3				
" soft		1	2				
Plumbers', coarse				1	3		480°
" ordinary				1	2		441
" fine				2	3		400°
Tinners'				1	1		370°
For tin pipe				3	2		330°
For tin pipe				4	4	1	

To Solder Aluminum. — The solder consists of aluminum 5 parts, antimony 5 parts, and zinc 90 parts. To make it harder, use a little more antimony and a little less zinc. The following is the process of making the solder and the method of using it:

The aluminum is first melted in a pot; the zinc is then added, and when this is melted, the antimony is added. The metal is then thoroughly puddled with sal ammoniac. When the surface of the metal is quite clear and white, it should be poured into sticks ready for use, the cinders being first removed.

To make joints in aluminum with this solder, the two or more surfaces to be joined should be cleaned, either by scraping or by using acid; and the surfaces should be well coated with the

solder, special care being taken that the solder penetrates into the surface of the metal without burning it. The parts to be joined should then be placed together and kept in close contact. Heat should now be applied till the solder melts, any surplus that squeezes out being wiped off.

Table showing quantity of 14″×20″ tin required to cover a given number of square feet with flat-seam tin roofing. A sheet of 14″×20″ with ½″ edges measures, when edged or folded, 13″×19″, or 247 square inches. In the following all fractional parts of a sheet are counted a full sheet.

Number of Sq. Ft.	Sheets Required.	Number of Sq. Ft.	Sheets Required.	Number of Sq. Ft.	Sheets Required.	Number of Sq. Ft.	Sheets Required.
100	59	330	193	560	327	780	455
110	65	340	199	570	333	790	461
120	70	350	205	580	339	800	467
130	76	360	210	590	344	810	473
140	82	370	216	600	350	820	479
150	88	380	222	610	356	830	484
160	94	390	228	620	362	840	490
170	100	400	234	630	368	850	496
180	105	410	240	640	374	860	502
190	111	420	245	650	379	870	508
200	117	430	251	660	385	880	514
210	123	440	257	670	391	890	519
220	129	450	263	680	397	900	525
230	135	460	269	690	403	910	531
240	140	470	275	700	409	920	537
250	146	480	280	710	414	930	543
260	152	490	286	720	420	940	549
270	158	500	292	730	426	950	554
280	164	510	298	740	432	960	560
290	170	520	304	750	438	970	566
300	175	530	309	760	444	980	572
310	181	540	315	770	449	990	578
320	187	550	321				

1000 square feet, 583 sheets. A box of 112 sheets 14″×20″ will cover approximately 192 square feet.

APPROXIMATE WEIGHTS.

Per Square of 100 Square Feet of Beaded Siding, Weatherboard Siding, Plain Brick, Rockface Brick and Rockface Stone Siding.

Gauge.	Beaded Siding.		Weatherboard Siding.		Plain Brick, Rockface Brick and Rockface Stone.	
	Painted.	Galvanized.	Painted.	Galvanized.	Painted.	Galvanized.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
28	70	85	75	91	64	78
27	76	91	82	98	71	85
26	83	98	89	106	77	91
24	110	125	119	135	....	....
22	....	....	148	164	....	....

U. S. STANDARD GAUGE. (FOR SHEET AND PLATE IRON AND STEEL.)

(Copy.) (Public—Number 137.)

An act establishing a standard gauge for sheet and plate iron and steel.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That for the purpose of securing uniformity the following is established as the only standard gauge for sheet and plate iron and steel in the United States of America, namely:

Number of Gauge.	Thickness.		Weight.		Number of Gauge.
	Approximate Thickness in Fractions of an Inch.	Approximate Thickness in Decimal Parts of an Inch.	Weight per Square Foot in Ounces Avoirdupois.	Weight per Square Foot in Pounds Avoirdupois.	
0000000	1/2	.5	320	20	0000000
000000	15/32	.46875	300	18.75	000000
00000	7/16	.4375	280	17.5	00000
0000	13/32	.40625	260	16.25	0000
000	3/8	.375	240	15	000
00	11/32	.34375	220	13.75	00
0	5/16	.3125	200	12.5	0
1	9/32	.28125	180	11.25	1
2	17/64	.265625	170	10.625	2
3	1/4	.25	160	10	3
4	15/64	.234375	150	9.375	4
5	7/32	.21875	140	8.75	5
6	13/64	.203125	130	8.125	6
7	3/16	.1875	120	7.5	7
8	11/64	.171875	110	6.875	8
9	5/32	.15625	100	6.25	9
10	9/64	.140625	90	5.625	10
11	1/8	.125	80	5	11
12	7/64	.109375	70	4.375	12
13	3/32	.09375	60	3.75	13
14	5/64	.078125	50	3.125	14
15	9/128	0703125	45	2.8125	15
16	1/16	.0625	40	2.5	16
17	9/160	.05625	36	2.25	17
18	1/20	.05	32	2	18
19	7/160	.04375	28	1.75	19
20	3/80	.0375	24	1.5	20
21	11/320	.034375	22	1.375	21
22	1/32	.03125	20	1.25	22
23	9/320	.028125	18	1.125	23
24	1/40	.025	16	1	24
25	7/320	.021875	14	.875	25
26	3/160	.01875	12	.75	26
27	11/640	.0171875	11	.6875	27
28	1/64	.015625	10	.625	28
29	9/640	.0140625	9	.5625	29
30	1/80	.0125	8	.5	30
31	7/640	.0109375	7	.4375	31
32	13/1280	.01015625	6½	.40625	32
33	3/320	.009375	6	.375	33
34	11/1280	.00859375	5½	.34375	34
35	5/640	.0078125	5	.3125	35
36	9/1280	.00703125	4½	.28125	36
37	17/2560	.006640625	4¼	.265625	37
38	1/160	.00625	4	.25	38

And on and after July first, eighteen hundred and ninety-three, the same and no other shall be used in determining duties and taxes levied by the United States of America on sheet and plate iron and steel. But this act shall not be construed to increase duties upon any articles which may be imported.

SEC. 2. That the Secretary of the Treasury is authorized and required to prepare suitable standards in accordance herewith.

SEC. 3. That in the practical use and application of the standard gauge hereby established a variation of two and one-half per cent either way may be allowed.

Approved March 3, 1893.

STANDING SEAM TIN ROOFING.—Table showing quantity of 20″×28″ tin required to cover a given number of square feet with standing seam roofing. The standing seams and the locks on a steep roof require 2¾″ off the width and ¾″ off the length of the sheet; fractional parts are counted as a full sheet. A sheet will cover 475 square inches.

Number of Sq. Ft.	Sheets Required.	Number of Sq. Ft.	Sheets Required.	Number of Sq. Ft.	Sheets Required.	Number of Sq. Ft.	Sheets Required.
100	31	330	100	560	173	780	237
110	34	340	103	570	176	790	240
120	37	350	106	580	182	800	243
130	40	360	109	590	185	810	246
140	43	370	112	600	184	820	249
150	46	380	115	610	135	830	252
160	49	390	118	620	188	840	255
170	52	400	122	630	191	850	258
180	55	410	125	640	194	860	261
190	58	420	128	650	197	870	264
200	61	430	131	660	200	880	267
210	64	440	134	670	203	890	270
220	67	450	137	680	206	900	273
230	70	460	140	690	207	910	276
240	73	470	143	700	212	920	279
250	76	480	147	710	215	930	282
260	79	490	149	720	218	940	285
270	82	500	152	730	221	950	288
280	85	510	158	740	224	960	291
290	88	520	161	750	228	970	294
300	91	530	164	760	231	980	297
310	94	540	167	770	234	990	300
320	97	550	170				

1000 square feet 303 sheets. A full box 112 sheets 20″×28″ will cover approximately 370 square feet.

The common sizes of tin plates are 10×14″ and multiples of that measure. The sizes most generally used are 14×20″ and 20×28″.

WEIGHT OF SHEETS PER SQUARE FOOT.

Black. United States Standard Weights.				Galvanized. National Association of Galvanized Sheet-iron Manufacturers' Weights.			
Number.	Pounds.	Number.	Pounds.	Number.	Ounces.	Number.	Ounces.
10	5.625	21	1.375	10	92½	21	24½
11	5	22	1.25	11	82½	22	22½
12	4.375	23	1.125	12	72½	23	20½
13	3.75	24	1	13	62½	24	18½
14	3.125	25	.875	14	52½	25	16½
15	2.8125	26	.75	15	47½	26	14½
16	2.5	27	.6875	16	42½	27	13½
17	2.25	28	.625	17	38½	28	12½
18	2	29	.5625	18	34½	29	11½
19	1.75	30	.5	19	30½	30	10½
20	1.50			20	26½		

COST OF TIN ROOFING PER SQUARE AND PER SQUARE FOOT

The following table shows the cost per square and per square foot of tin roofing, laid with 14 × 20 tin, with tin at any price from $4 to $10 per box. The first column contains the price per box of tin; the second column shows the cost of tin per square (100 square feet) of surface, and the third column shows the cost of tin per square foot of surface.

Flat Seam Roofing — Cost with 14×20 Tin.

Price of Tin per Box.	Cost per Square of Flat Roof 14 × 20 Tin.	Cost per Square Foot.	Price of Tin per Box.	Cost per Square of Flat Roof 14 × 20 Tin.	Cost per Square Foot.
$4.25	$2.21	.0221	$8.25	$4.29	.0420
4.50	2.34	.0234	8.50	4.42	.0442
4.75	2.47	.0247	8.75	4.55	.0455
5.00	2.60	.0260	9.00	4.68	.0468
5.25	2.73	.0273	9.25	4.81	.0481
5.50	2.86	.0286	9.50	4.94	.0494
5.75	2.99	.0299	9.75	5.07	.0507
6.00	3.12	.0312	10.00	5.20	.0520
6.25	3.25	.0325	10.25	5.33	.0533
6.50	3.38	.0338	10.50	5.46	.0546
6.75	3.51	.0351	10.75	5.59	.0559
7.00	3.64	.0364	11.00	5.72	.0572
7.25	3.77	.0377	11.25	5.85	.0585
7.50	3.90	.0390	11.50	5.98	.0598
7.75	4.03	.0403	11.75	6.11	.0611
8.00	4.16	.0416	12.00	6.24	.0624

Standing Seam Roofing — Cost with 14×20 Tin.

Price of Tin per Box.	Cost per Square of Standing Seam Roof with 14×20 Tin.	Cost per Square Foot.	Price of Tin per Box.	Cost per Square of Standing Seam Roof with 14×20 Tin.	Cost per Square Foot.
$4.25	$2.37	.0237	$7.25	$4.03	.0403
4.50	2.51	.0251	7.50	4.17	.0417
4.75	2.65	.0265	7.75	4.31	.0431
5.00	2.79	.0279	8.00	4 45	.0445
5.25	2.93	.0293	8.25	4.59	.0459
5.50	3.06	.0306	8.50	4.73	.0473
5.75	3.20	.0320	8.75	4.87	.0487
6.00	3.34	.0334	9 00	5.01	.0501
6.25	3.48	.0348	9.25	5.15	.0515
6.50	3.62	.0362	9.50	5.29	.0529
6.75	3.76	.0376	9.75	5.43	.0543
7.00	3.90	.0390	10.00	5.57	.0557

COST OF TIN ROOFING PER SQUARE — (*Continued*)

Flat seam Roofing — Cost with 20×28 Tin.

Price of Tin per Box.	Cost per Square of Flat Roof 20×28 Tin.	Cost per Square Foot.	Price of Tin per Box.	Cost per Square of Flat Roof 20×28 Tin.	Cost per Square Foot.
$8.00	$2.01	.0201	$16.00	$4.00	.0401
8.50	2.13	.0213	16.50	4.13	.0413
9.00	2.26	.0226	17.00	4.26	.0426
9.50	2.38	.0238	17.50	4.38	.0438
10.00	2.51	.0251	18.00	4.51	.0451
10.50	2.63	.0263	18.50	4.63	.0463
11.00	2.76	.0276	19.00	4.76	.0476
11.50	2.88	.0288	19.50	4.88	.0488
12.00	3.00	.0300	20.00	5.01	.0501
12.50	3.13	.0313	20.50	5.13	.0513
13.00	3.25	.0325	21.00	5.26	.0526
13.50	3.38	.0338	21.50	5.38	.0538
14.00	3.50	.0350	22.00	5.51	.0551
14.50	3.63	.0363	22.50	5.63	.0563
15.00	3.75	.0375	23.00	5.76	.0576
15.50	3.88	.0388			

Standing Seam Roofing — Cost with 20×28 Tin.

Price of Tin per Box.	Cost per Square of Standing Seam Roof with 20×28 Tin.	Cost per Square Foot.	Price of Tin per Box.	Cost per Square of Standing Seam Roof with 20×28 Tin.	Cost per Square Foot.
$8.00	$2.15	.0215	$16.50	$4.42	.0442
8.00	2.28	.0228	17.00	4.56	.0456
9.00	2.41	.0241	17.50	4.69	.0469
9.50	2.55	.0255	18.00	4.82	.0482
10.00	2.68	.0268	18.50	4.96	.0496
10.50	2.82	.0282	19.00	5.09	.0509
11.00	2.95	.0295	19.50	5.23	.0523
11.50	3.09	.0309	20.00	5.36	.0536
12.00	3.21	.0321	20.50	5.49	.0549
12.50	3.35	.0335	21.00	5.63	.0563
13.00	3.48	.0348	21.50	5.76	.0576
13.50	3.62	.0362	22.00	5.90	.0590
14.00	3.75	.0375	22.50	6.03	.0603
14.50	3.89	.0389	23.00	6.17	.0617
15.00	4.02	.0402	23.50	6.30	.0630
15.50	4.15	.0415	24.00	6.43	.0643
16.00	4.29	.0429			

WEIGHT OF BLACK PLATES BEFORE BEING COATED.

	IC 14×20	IC 20×28	IX 14×20	IX 20×28
Black plates before coating weigh per 112 sheets....	Lbs. 95 to 100	Lbs. 190 to 200	Lbs. 125 to 130	Lbs. 250 to 260

NET WEIGHT PER BOX TIN PLATES.

Basis 14×20, 112.

Trade term....		80-lb	85-lb	90-lb	95-lb	100-lb	IC	IXL	IX	IXX	IXXX	IXXXX
Weight per box, lbs.		80	85	90	95	100	107	128	135	155	175	195
Nearest wire-gauge No.....		33	32	31	31	30	30	28	28	27	26	25
Size of Sheets.	Sheets per Box.											
10 ×14	225	80	85	90	95	100	107	128	135	155	175	195
14 ×20	112	80	85	90	95	100	107	128	135	155	175	195
20 ×28	112	160	170	180	190	200	214	256	270	310	350	390
10 ×20	225	114	121	129	136	143	153	183	193	221	250	279
11 ×22	225	138	147	156	164	172	184	222	234	268	302	337
11½×23	225	151	161	170	179	189	202	242	255	293	331	368
12 ×12	225	82	87	93	98	103	110	132	139	159	180	201
12 ×24	112	82	87	93	98	103	110	132	139	159	180	201
13 ×13	225	97	103	109	115	121	129	154	163	187	211	235
13 ×26	112	97	103	109	115	121	129	154	163	187	211	235
14 ×14	225	112	119	126	133	140	150	179	189	217	245	273
14 ×28	112	112	119	126	133	140	150	179	189	217	245	273
15 ×15	225	129	137	145	153	161	172	206	217	249	281	313
16 ×16	225	146	155	165	174	183	196	234	247	283	320	357
17 ×17	225	165	175	186	196	206	221	264	279	320	361	403
18 ×18	112	93	98	104	110	116	124	148	156	179	202	226
19 ×19	112	103	110	116	122	129	138	165	174	200	226	251
20 ×20	112	114	121	129	136	143	153	183	193	221	250	279
21 ×21	112	126	134	142	150	158	169	202	213	244	276	307
22 ×22	112	138	147	156	164	172	184	221	234	268	302	337
23 ×23	112	151	161	170	179	189	202	242	255	293	331	368
24 ×24	112	164	175	185	195	204	220	263	278	319	360	401
26 ×26	112	193	205	217	229	241	258	309	326	374	422	471
16 ×20	112	91	97	103	109	114	122	146	154	177	200	223
14 ×31	112	124	132	140	147	155	166	198	209	240	271	302
11¼×22¾	112	73	78	82	87	91	98	...	...	....	.....	......
13¼×17¾	112	67	71	76	80	84	90	...	...	....	.....	......
13¼×19¼	112	73	77	82	87	91	97	...	...	....	.....	......
13½×19½	112	75	80	85	89	94	100	...	...	....	.....	......
13½×19¾	112	76	81	86	90	95	102	...	...	....	.....	......
14 ×18¾	124	83	88	93	98	103	110	...	...	....	.....	......
14 ×19¼	120	83	88	93	98	103	110	...	...	....	.....	......
14 ×21	112	84	89	95	100	105	112	...	...	....	.....	......
14 ×22	112	88	94	99	105	110	118	...	...	....	.....	......
14 ×22¼	112	89	95	100	106	111	119	...	...	....	.....	......
15½×23	112	102	108	115	121	127	136	...	...	....	.....	......

WEIGHT, GAUGE, ETC., OF BRIGHT COKE FINISH TIN PLATE, HEATER PIPE SIZES.

Gauge.	Thickness.	Size.	Sheets.	Net Weight.
30	IC	20×23	112	176
30	IC	20×26	112	199
30	IC	20×29½	112	225
30	IC	20×32½	112	248
30	IC	20×35¾	112	273
30	IC	20×38½	112	294
28	IX	20×23	112	222
28	IX	20×26	112	251
28	IX	20×29½	112	284
28	IX	20×32½	112	313
28	IX	20×35¾	112	345
28	IX	20×38½	112	371

STANDARD WEIGHTS AND GAUGES, D PLATES

Trade term	DC	DX	DXX	DXXX	DXXXX
Actual weight, per sq. ft. lbs.......	.637	.826	.962	1.10	1.23
Nearest equivalent in I plates	IX	IXXX	IXXXXX	IXXXXXX	IXXXXXXX
12½×17, 100 sheets, weight per box, lbs.............	94	122	142	162	182
17×25, 50 sheets, weight per box, lbs.............	94	122	142	162	182
15×21, 100 sheets, weight per box, lbs.............	140	181	211	241	271

HOW TO ESTIMATE ON QUANTITY AND COST OF CORRUGATED SHEETS.

First, select the best lengths of sheets that will fit the space you intend covering, not forgetting the end laps.

On siding, a one-inch or two-inch end lap is sufficient, but on roofing it varies from three to six inches, according to pitch of roof.

Our common 2½-inch corrugated sheets will lay 24 inches wide with a side lap of one corrugation, but the selling measurement is 26 inches wide.

A 6-foot sheet will measure 13 square feet and lay 12 square feet.
" 7 " " " " 15⅙ " " " " 14 " "
" 8 " " " " 17⅓ " " " " 16 " "
" 9 " " " " 19½ " " " " 18 " "
" 10 " " " " 21⅔ " " " " 20 " "

In the above table, end laps are not considered.

You make your own allowance for end laps.

The extreme length of corrugated sheets is 10 feet.

NUMBER AND WEIGHT OF CORRUGATED IRON AND STEEL SHEETS.

Number of Corrugated Sheets in One Square (100 Square Feet).

Length of Sheet, Inches.	3-Inch Corrugations. Width (flat) 28 Inches. Width (after corrugating) 26 Inches.	$2\frac{1}{2}$-Inch Corrugations. Width (flat) 28 Inches. Width (after corrugating) 26 Inches.	$1\frac{1}{4}$-Inch Corrugations. Width (flat) 28 Inches. Width (after corrugating) 25 Inches.
72	7.692	7.692	8.000
84	6.593	6.593	6.857
96	5.769	5.769	6.000
108	5.128	5.128	5.333
120	4.616	4.616	4.800

Weight of Corrugated Sheets per Square or 100 Square Feet (Pounds).

Gauge Number.	Black.			Galvanized.		
	3-Inch Corrugations.	$2\frac{1}{2}$-Inch Corrugations.	$1\frac{1}{4}$-Inch Corrugations.	3-Inch Corrugations.	$2\frac{1}{2}$-Inch Corrugations.	$1\frac{1}{4}$-Inch Corrugations.
20	162	162	168	179	179	186
21	148	148	154	165	165	171
22	135	135	140	152	152	157
23	121	121	126	138	138	143
24	108	108	112	124	124	129
25	94	94	98	112	112	115
26	81	81	84	98	98	102
27	74	74	77	91	91	95
28	67	67	70	85	85	88

For painted sheets add 2 pounds for paint.

$2\frac{1}{2}$-inch and 3-inch corrugations — Width after corrugating, 26 inches; approximate covering width (allowing for laps), 24 inches.

$1\frac{1}{4}$-inch corrugations — Width after corrugating, 25 inches; approximate covering width (allowing for laps), 24 inches.

Corrugated sheets, black and galvanized, plain and painted: 5-inch, 3-inch, $2\frac{1}{2}$-inch, $1\frac{1}{4}$-inch and $\frac{5}{8}$-inch corrugations.

SIZE AND WEIGHT OF CHURCH AND SCHOOL BELLS.

Inches in Diameter.	Weight of Bell Only.	Weight of Bell and Mounting.
School and chapel bells.		
20-inch	105 lbs.	150 lbs.
22- "	125 "	175 "
24- "	155 "	225 "
26- "	215 "	325 "
28- "	250 "	400 "
30- " without toller	320 "	525 "
Church bells.		
30-inch with toller	330 "	535 "
32- " " "	330 "	575 "
34- " " "	460 "	725 "
36- " " "	550 "	800 "
38- " " "	650 "	950 "
40- " " "	800 "	1100 "
42- " " "	900 "	1200 "
44- " " "	1050 "	1450 "
46- " " "	1150 "	1600 "
48- " " "	1350 "	1850 "

APPROXIMATE DIMENSIONS OF TINNERS' RIVETS.

Revised October 21, 1884.

Size.	Length.	Diameter, Wire Gauge.	Size.	Length.	Diameter, Wire Gauge.
8 oz.	$\frac{5}{32}$	No. 13¼	3½ lbs.	$\frac{21}{64}$	No. 8
10 "	$\frac{11}{64}$	" 13	4 "	$\frac{11}{32}$	" 7¼
12 "	$\frac{3}{16}$	" 12¼	5 "	$\frac{3}{8}$	" 6¾
14 "	$\frac{3}{16}$	" 12	6 "	$\frac{25}{64}$	" 6
1 lb.	$\frac{13}{64}$	" 11¾	7 "	$\frac{13}{32}$	" 5¼
1¼ "	$\frac{7}{32}$	" 11	8 "	$\frac{7}{16}$	" 4¾
1½ "	$\frac{15}{64}$	" 10¼	9 "	$\frac{29}{64}$	" 4¼
1¾ "	$\frac{1}{4}$	" 10	10 "	$\frac{15}{32}$	" 4
2 lbs.	$\frac{17}{64}$	" 9¼	12 "	$\frac{1}{2}$	" 3
2½ "	$\frac{9}{32}$	" 9	14 "	$\frac{33}{64}$	" 2
3 "	$\frac{5}{16}$	" 8¼	16 "	$\frac{17}{32}$	" 1

WEIGHTS OF LUMBER.

ESTIMATED WEIGHTS OF WHITE PINE.

	Pounds per Thousand Feet.	
	Green.	Dry.
Timbers, rough	3250	2500
Lumber, rough	3000	2400
Lumber, dressed	2500	2000
Lumber, D. and M.	2400	1800
Battens, O. G	1900	1500
Siding and ⅜ ceiling	1250	800
Shingles	450	250
Lath	950	500

TABLES SHOWING NUMBER OF RIVETS AND BURS TO THE POUND.

Oval Head, or Trunk, Rivets and Burs.

Length Measured under the Head.

No.	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	Burs.
9	317	270	254	220	206	193	189	165	138	116	107	101	600

COPPER BRAZIER'S RIVETS.

Oval Head.

Length Measured under the Head.

Numbers. . .	00	0	1	2	3	4	5	6	7	8	9	10
Number to pound. . . .	160	148	66	49	37	28	23	19	13	8	6	5
Diameter of shank. . . .	$\frac{5}{32}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{17}{64}$	$\frac{9}{32}$	$\frac{5}{16}$	$\frac{23}{64}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{17}{32}$	$\frac{5}{8}$	$\frac{21}{32}$
Length, Ins.	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{15}{16}$	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{1}{4}$

FLAT-HEAD COPPER RIVETS.

Length Measured under the Head.

$\frac{1}{4}$ in. diameter of shank. . . . . ×		$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$ in long
Number to pound		48	36	32	30
$\frac{5}{16}$ in. diameter of shank. . . . . ×		$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$ in long
Number to pound		26	24	21	17
$\frac{3}{8}$ in. diameter of shank . . . . ×	1	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	2 in long
Number to pound	17	15	13	12	10
$\frac{1}{2}$ in. diameter of shank. . . . . ×	1	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	2 in long
Number to pound	9	8	7	6	5

TABLE SHOWING NUMBER OF STAR BRAND BRASS ESCUTCHEON PINS TO THE POUND.

Length Measured under the Head.

No.	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2
12	. . . . .	720	650	460	416	400	336	272	212	192	170
13	. . . . .	1120	948	672	528	480	400	380	320	229	220
14	1875	1312	1100	950	830	692	600	432	378	320	272
15	2440	1820	1376	1152	960	888	720	576	580	432	400
16	3100	2240	1720	1460	1275	1130	980	720	592	578	464
17	3540	2700	2076	1812	1500	1185	1051	928	800	640	
18	4972	3175	2550	2450	2200	1740	1520	1216	960		
19	7303	5140	4130	3565	2900						
20	9932	8419	6374	5500	4155						

WEIGHTS OF STAIR PLATES, STOCK SIZES.

	5×18	5×20	6×18	6×20
Zinc.	$1\frac{3}{8}$	$1\frac{7}{16}$	$1\frac{9}{16}$	$1\frac{5}{8}$ lbs,
Brass	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{7}{8}$	2 "

These tables are theoretically correct, but variations must be expected in practice.

TABLE OF WEIGHTS OF IRON AND STEEL SHEETING PER SQUARE FOOT. (*Kent.*)

Thickness by Stubs' or Birmingham Gauge.				Thickness by American (Brown & Sharpe's) Gauge.			
No. of Gauge.	Thickness in Inches.	Iron.	Steel.	No. of Gauge.	Thickness in Inches.	Iron.	Steel.
0000	.454	18.16	18.52	0000	.46	18.40	18.77
000	.425	17.00	17.34	000	.4096	16.38	16.71
00	.38	15.20	15.30	00	.3648	14.59	14.88
0	.34	13.60	13.87	0	.3249	13.00	13.26
1	.3	12.00	12.24	1	.2893	11.57	11.80
2	.284	11.36	11.59	2	.2576	10.30	10.51
3	.259	10.36	10.57	3	.2294	9.18	9.36
4	.238	9.52	9.71	4	.2043	8.17	8.34
5	.22	8.80	8.98	5	.1819	7.28	7.42
6	.203	8.12	8.28	6	.1620	6.48	6.61
7	.18	7.20	7.34	7	.1443	5.77	5.89
8	.165	6.60	6.73	8	.1285	5.14	5.24
9	.148	5.92	6.04	9	.1144	4.58	4.67
10	.134	5.36	5.47	10	.1019	4.08	4.16
11	.12	4.80	4.90	11	.0907	3.63	3.70
12	.109	4.36	4.45	12	.0808	3.23	3.30
13	.095	3.80	3.88	13	.0720	2.88	2.94
14	.083	3.32	3.39	14	.0641	2.56	2.62
15	.072	2.88	2.94	15	.0571	2.28	2.33
16	.065	2.60	2.65	16	.0508	2.03	2.07
17	.058	2.32	2.37	17	.0453	1.81	1.85
18	.049	1.96	2.00	18	.0403	1.61	1.64
19	.042	1.68	1.71	19	.0359	1.44	1.46
20	.035	1.40	1.43	20	.0320	1.28	1.31
21	.032	1.28	1.31	21	.0285	1.14	1.16
22	.028	1.12	1.14	22	.0253	1.01	1.03
23	.025	1.00	1.02	23	.0226	.904	.922
24	.022	.88	.898	24	.0201	.804	.820
25	.02	.80	.816	25	.0179	.716	.730
26	.018	.72	.734	26	.0159	.636	.649
27	.016	.64	.653	27	.0142	.568	.579
28	.014	.56	.571	28	.0126	.504	.514
29	.013	.52	.530	29	.0113	.452	.461
30	.012	.48	.490	30	.0100	.400	.408
31	.01	.40	.408	31	.0089	.356	.363
32	.009	.36	.367	32	.0080	.320	.326
33	.008	.32	.326	33	.0071	.284	.290
34	.007	.28	.286	34	.0063	.252	.257
35	.005	.20	.204	35	.0056	.224	.228

	Iron.	Steel.
Specific gravity	7.7	7.854
Weight per cubic foot	480	489.6
" " " inch	.2778	.2833

As there are many gauges in use differing from each other, and even the thicknesses of a certain specified gauge, as the Birmingham, are not assumed the same by all manufacturers, orders for sheets and wires should always state the weight per square foot or the thickness in thousandths of an inch.

TABLE OF WEIGHTS PER SQUARE FOOT OF COPPER AND BRASS SHEETS.

American or B. & S. Gauge.		Copper. Pounds.	Brass. Pounds.
Number.	Thickness.		
0000	.46 inch, or $\frac{7}{16}$ inch full	20.838	19.688
000	.40964 inch	18.557	17.533
00	.3648 " , or $\frac{3}{8}$ inch scant	16.525	15.613
0	.32486 "	14.716	13.904
1	.2893 "	13.105	12.382
2	.25763 inch, or $\frac{1}{4}$ inch full	11.670	11.027
3	.22942 "	10.392	9.819
4	.20431 "	9.255	8.745
5	.18194 " , or $\frac{3}{16}$ inch scant	8.242	7.788
6	.16202 "	7.340	6.935
7	.14428 inch	6.536	6.175
8	.12849 " , or $\frac{1}{8}$ inch full	5.821	5.499
9	11443 "	5.183	4.898
10	.10189 "	4.616	4.361
11	.090742 "	4.110	3.884
12	.0808 inch	3.66	3.457
13	.0720 "	3.26	3.08
14	.06408 "	2.90	2.743
15	.057068 "	2.585	2.442
16	.05082 "	2.302	2.175
17	.045257 inch	2.05	1.937
18	.0403 "	1.825	1.725
19	.0359 "	1.626	1.536
20	.0320 "	1.448	1.367
21	.02846 "	1.289	1.218
22	.02535 inch	1.148	1.085
23	.02257 "	1.023	.966
24	.0211 "	.910	.860
25	.0179 "	.811	.766
26	.0159 "	.722	.682
27	.01419 inch	.643	.608
28	.01264 "	.573	.541
29	.01126 "	.510	.482
30	.01003 "	.454	.429
31	.0089 "	.404	.382
32	.0079 inch	.360	.340
33	.0071 "	.321	.303
34	.0063 "	.286	.269
35	.0056 "	.254	.240
36	.0050 "	.226	.214
37	.00445 inch	.202	.191
38	.00396 "	.180	.170
39	.00353 "	.160	.151
40	.00314 "	.142	.135

These weights are theoretically correct, but variations must be expected in practice.

TABLE OF WEIGHTS PER SQUARE FOOT OF COPPER AND BRASS SHEETS—(*Continued*).

Stubs' Gauge.		Copper. Pounds.	Brass. Pounds.
Number.	Thickness.		
0000	.464 inch, or 7/16 inch full	20.556	19.431
000	.425 "	19.253	18.19
00	.380 " , or 3/8 inch full	17.214	16.264
0	.340 " " 11/32 " scant	15.402	14.552
1	.300 " " 19/64 " full	13.59	12.84
2	.284 inch, or 9/32 inch full	12.865	12.155
3	.259 " " 1/4 " "	11.733	11.09
4	.238 " " 15/64 " "	10.781	10.19
5	.220 " " 7/32 " "	9.966	9.416
6	.203 " " 13/64 " "	9.20	8.689
7	.180 inch, or 13/16 inch scant	8.154	7.704
8	.165 " " 11/64 " "	7.475	7.062
9	.148 " " 9/64 " full	6.704	6.334
10	.134 " " 9/64 " scant	6.070	5.735
11	.120 " " 1/8 " "	5.436	5.137
12	.109 inch, or 7/64 inch	4.938	4.667
13	.095 " " 3/32 " full	4.303	4.066
14	.083 " " 5/64 " "	3.760	3.552
15	.072 " " 5/64 " scant	3.262	3.08
16	.065 " " 1/16 " full	2.945	2.78
17	.058 inch, or 1/16 inch scant	2.627	2.48
18	.049 " " 3/64 " full	2.220	2.10
19	.042 " " 3/64 " scant	1.90	1.80
20	.035 " " 1/32 " full	1.59	1.50
21	.032 " " 1/32 " scant	1.45	1.37
22	.028 inch	1.27	1.20
23	.025 "	1.13	1.07
24	.022 "	.997	.941
25	.020 "	.906	.856
26	.018 "	.815	.770
27	.016 inch, or 1/64 inch	.725	.685
28	.014 "	.634	.599
29	.013 "	.589	.556
30	.012 "	.544	.514
31	.010 "	.453	.428
32	.009 inch	.408	.385
33	.008 "	.362	.342
34	.007 "	.317	.2996
35	.005 "	.227	.214
36	.004 "	.181	.171

WEIGHT OF ALUMINUM SHEETS.

Brown & Sharpe's Gauge.

No.	B. & S. G. Decimal Parts of an Inch.	Corresponding Fractional Part of an Inch.	Wt. per Sq. Foot Aluminum. Lbs.	No.	B. & S. G. Decimal Parts of an Inch.	Corresponding Fractional Part of an Inch.	Wt. per Sq. Foot Aluminum. Lbs.	No.	B. &. S. G. Decimal Parts of an Inch.	Wt. per Sq. Foot Aluminum. Lbs.
0000	.460	$\frac{15}{32}$	6.406	13	.072	......	1.002	29	.011	.157
000	.410	......	5.704	14	.064	$\frac{1}{16}$	.892	30	.010	.140
00	.365	$\frac{3}{8}$	5.080	15	.057	......	.795	31	.009	.124
0	.325	$\frac{21}{64}$	4.524	16	.051	......	.708	32	.00795	.1107
1	.289	$\frac{9}{32}$	4.029	17	.045	$\frac{3}{64}$	.630	33	.00708	.0985
2	.258	$\frac{1}{4}$	3.588	18	.040	......	.561	34	.0063	.0877
3	.229	$\frac{15}{64}$	3.195	19	.036	......	.500	35	.0056	.0782
4	.204	$\frac{13}{64}$	2.845	20	.032	$\frac{1}{32}$	.445	36	.005	.0696
5	.182	$\frac{3}{16}$	2.534	21	.028	......	.396	37	.00445	.0620
6	.162	$\frac{5}{32}$	2.256	22	.025	......	.353	38	.00396	.0552
7	.144	$\frac{9}{64}$	2.009	23	.023	......	.314	39	.00353	.0491
8	.128	$\frac{1}{8}$	1.789	24	.020	......	.280	40	.00314	.0438
9	.114	$\frac{7}{64}$	1.594	25	.018	......	.249	41	.0028	
10	.102	......	1.418	26	.016	$\frac{1}{64}$	.222	42	.00249	
11	.091	$\frac{3}{32}$	1.264	27	.014	......	.197			
12	.081	$\frac{5}{64}$	1.126	28	.013	......	.176			

To obtain the weight of aluminum in bars, sheets, etc., divide the weight of similar pieces of copper by 3.3, brass by 3.1 and steel by 2.9.

WEIGHT OF ASBESTOS MILL BOARD.

Made in sheets 42 × 44 inches. $\frac{1}{32}$ to $\frac{1}{2}$ inch thick.
The approximate weights of sheets are as follows:

Thickness,	$\frac{1}{32}$	$\frac{1}{16}$	$\frac{3}{32}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	inch.
Weights,	$1\frac{3}{4}$	$3\frac{1}{2}$	$5\frac{1}{4}$	7	$10\frac{1}{2}$	14	21	28	pounds.

WEIGHT OF PLATE GLASS.

Plate glass weighs about $3\frac{1}{2}$ lbs per square foot.

WEIGHT OF ZINC PER SHEET.

U. S. Standard Gauge.	M. & H. Zinc Gauge.	24×84	26×84	28×84	30×84	32×84	34×84
28	8	8.4	9.1	9.8	10.5	11.2	11.9
26–27	9	9.4	10.2	10.9	11.7	12.5	13.3
25	10	10.5	11.4	12.3	13.1	14.0	14.9
24	11	12.6	13.7	14.7	15.8	16.8	17.8
23	12	14.7	15.9	17.1	18.4	19.6	20.8
22	13	16.8	18.2	19.6	21.0	22.4	23.8
21	14	18.9	20.5	22.0	23.6	25.1	26.8
20	15	21.0	22.7	24.5	26.2	28.0	29.7

U. S. Standard Gauge.	M. & H. Zinc Gauge.	36×84	40×84	42×84	46×84	48×84	52×84
28	8	12.6	14.0	14.7	16.1	16.8	18.2
26–27	9	14.1	15.6	16.4	18.0	18.8	20.3
25	10	15.7	17.5	18.4	20.1	21.0	22.7
24	11	18.9	21.0	22.0	24.0	25.2	27.3
23	12	22.0	24.5	25.7	28.2	29.4	31.8
22	13	25.2	28.0	29.4	32.2	33.6	36.4
21	14	28.3	31.5	33.1	36.2	37.8	40.9
20	15	31.5	35.0	36.7	40.2	42.0	45.5

Zinc gauge can be maintained only approximately.

THICKNESS AND WEIGHT PER SQUARE FOOT OF SHEET TIN.

1 pound tin is $\frac{1}{40}$ inch thick.
$1\frac{1}{2}$ pound tin is $\frac{1}{21}$ inch thick.
2 pound tin is $\frac{1}{20}$ inch thick.
$2\frac{1}{2}$ pound tin is $\frac{1}{16}$ inch thick.
3 pound tin is $\frac{1}{13}$ inch thick.
$3\frac{1}{2}$ pound tin is $\frac{1}{11}$ inch thick.
4 pound tin is $\frac{1}{10}$ inch thick.
$4\frac{1}{2}$ pound tin is $\frac{1}{9}$ inch thick.
5 pound tin is $\frac{1}{8}$ inch thick.
10 pound tin is $\frac{1}{4}$ inch thick.
20 pound tin is $\frac{1}{2}$ inch thick.

SIZE AND WEIGHT PER SHEET OF WOOD'S PATENT-PLANISHED IRON.

Table of Standard Sizes showing Weights of Sheets in Pounds.

Gauges. Approx. Russia Gauge.	18 —	19 —	20 —	21 —	22 14	23 13	Sq. Ft. per Sheet.
28×45	16.25 to 17	14.75 to 15.25	12 to 12.5	11 to 11.5	10 to 10.25	9.25 to 9.5	8.75
28×48	17.25 to 18	15.75 to 16.25	13 to 13.5	12 to 12.5	10.5 to 10.75	10 to 10.25	9.33
28×56	20.25 to 21	18.25 to 18.75	14.75 to 15.25	14 to 14.5	12.25 to 12.5	11.25 to 11.5	10.89
28×60	21.5 to 21.75	19.5 to 20	16.25 to 16.75	14.75 to 15.25	13.25 to 13.5	12.5 to 12.75	11.66
28×72	26 to 27	23.5 to 24	18.5 to 19	17.75 to 18.25	16 to 16.25	15.25 to 15.5	14
28×84	30.5 to 31.25	27.5 to 28	22.75 to 23.5	20.75 to 21.25	18.75 to 19	17.25 to 17.5	16.33
30×45	17.25 to 18	15.75 to 16.5	13 to 13.75	12 to 12.75	10.25 to 10.75	10.25 to 10.5	9.37
30×48	18.25 to 19	16.75 to 17.5	14 to 14.75	13 to 13.5	11.25 to 11.75	10.75 to 11.25	10
30×56	21.25 to 22	19.5 to 20	16.25 to 16.75	15 to 15.5	13.25 to 13.75	12.5 to 13	11.66
30×60	23 to 23.75	21 to 21.5	17.25 to 17.75	16.25 to 16.75	14.25 to 14.75	13.5 to 14	12.5
30×72	27.5 to 28.25	25.25 to 25.75	20.75 to 21.25	19.5 to 19.75	17 to 17.75	16.25 to 16.75	15
30×84	32.25 to 33	29.5 to 30	24.5 to 25	21.5 to 23	19.75 to 20.25	19 to 19.5	17.5

Gauges. Approx. Russia Gauge.	24 12	25 11	26 10	27 9	28 8		Sq. Ft. per Sheet.
28×45	8.25 to 8.5	7.25 to 7.5	6.5 to 6.75	6.25 to 6.5	5.5 to 5.75	....	8.75
28×48	8.75 to 9	7.75 to 8	7 to 7.25	6.75 to 7.25	6 to 6.25	....	9.33
28×56	10.25 to 10.5	9 to 9.5	8.25 to 8.5	7.75 to 8.25	6.75 to 7.25	....	10.89
28×60	10.75 to 10.25	9.75 to 10.25	8.75 to 9.25	8 to 8.5	7.5 to 8	....	11.66
28×72	13.25 to 13.5	11.75 to 12.25	10.75 to 11	10 to 10.5	9 to 9.5	....	14
28×84	15.5 to 16	13.75 to 14.25	12.75 to 13	11.5 to 12	10.5 to 11	....	16.33
30×45	8.5 to 9	7.5 to 8	7 to 7.25	6.5 to 6.75	6 to 6.25	....	9.37
30×48	9.25 to 9.75	8.25 to 8.75	7.5 to 8	7 to 7.5	6.5 to 6.75	....	10
30×56	11.25 to 11.75	9.5 to 9.75	9 to 9.25	8.25 to 8.5	7.25 to 7.5	....	11.66
30×60	12 to 12.5	10.25 to 10.75	9.5 to 9.75	9 to 9.25	8 to 8.25	....	12.5
30×72	14 to 14.75	12.25 to 12.75	11.5 to 11.75	10.25 to 10.75	9.5 to 9.75	....	15
30×84	16.25 to 16.75	14.25 to 14.75	13.5 to 13.75	12.25 to 12.75	11.25 to 11.5	....	17.5

WEIGHT OF SHEETS OF WROUGHT IRON, STEEL, COPPER, AND BRASS (from Haswell).

Weights per square foot. Thickness by Birmingham Gauge.

Number of Gauge.	Thickness in Inches.	Iron.	Steel.	Copper.	Brass.
0000	.454	18.22	18.46	20.57	19.43
000	.425	17.05	17.28	19.25	18.19
00	.38	15.25	15.45	17.21	16.26
0	.34	13.64	13.82	15.40	14.55
1	.3	12.04	12.20	13.59	12.84
2	.284	11.40	11.55	12.87	12.16
3	.259	10.39	10.53	11.73	11.09
4	.238	9.55	9.68	10.78	10.19
5	.22	8.83	8.95	9.97	9.42
6	.203	8.15	8.25	9.20	8.69
7	.18	7.22	7.32	8.15	7.70
8	.165	6.62	6.71	7.47	7.06
9	.148	5.94	6.02	6.70	6.33
10	.134	5.38	5.45	6.07	5.74
11	.12	4.82	4.88	5.44	5.14
12	.109	4.37	4.43	4.94	4.67
13	.095	3.81	3.86	4.30	4.07
14	.083	3.33	3.37	3.76	3.55
15	.072	2.89	2.93	3.26	3.08
16	.065	2.61	2.64	2.94	2.78
17	.058	2.33	2.36	2.63	2.48
18	.049	1.97	1.99	2.22	2.10
19	.042	1.69	1.71	1.90	1.80
20	.035	1.40	1.42	1.59	1.50
21	.032	1.28	1.30	1.45	1.37
22	.028	1.12	1.14	1.27	1.20
23	.025	1.00	1.02	1.13	1.07
24	.022	.883	.895	1.00	.942
25	.02	.803	.813	.906	.856
26	.018	.722	.732	.815	.770
27	.016	.642	.651	.725	.685
28	.014	.562	.569	.634	.599
29	.013	.522	.529	.589	.556
30	.012	.482	.488	.544	.514
31	.01	.401	.407	.453	.428
32	.009	.361	.366	.408	.385
33	.008	.321	.325	.362	.342
34	.007	.281	.285	.317	.300
35	.005	.201	.203	.227	.214
Specific gravity....		7.704	7.806	8.698	8.218
Weight cubic foot..		481.75	487.75	543.6	513.6
Weight cubic inch..		.2787	.2823	.3146	.2972

WEIGHT OF SHEETS OF WROUGHT IRON, STEEL, COPPER AND BRASS (from Haswell).

Weights per sq. ft. Thickness by American (Browne & Sharpe's) Gauge.

Number of Gauge.	Thickness in Inches.	Iron.	Steel.	Copper.	Brass.
0000	.46	18.46	18.70	20.84	19.69
000	.4096	16.44	16.66	18.56	17.53
00	.3648	14.64	14.83	16.53	15.61
0	.3249	13.04	13.21	14.72	13.90
1	.2893	11.61	11.76	13.11	12.38
2	.2576	10.34	10.48	11.67	11.03
3	.2294	9.21	9.33	10.39	9.82
4	.2043	8.20	8.31	9.26	8.74
5	.1819	7.30	7.40	8.24	7.79
6	.1620	6.50	6.59	7.34	6.93
7	.1443	5.79	5.87	6.54	6.18
8	.1285	5.16	5.22	5.82	5.50
9	.1144	4.59	4.65	5.18	4.90
10	.1019	4.09	4.14	4.62	4.36
11	.0907	3.64	3.69	4.11	3.88
12	.0808	3.24	3.29	3.66	3.46
13	.0720	2.89	2.93	3.26	3.08
14	.0641	2.57	2.61	2.90	2.74
15	.0571	2.29	2.32	2.59	2.44
16	.0508	2.04	2.07	2.30	2.18
17	.0453	1.82	1.84	2.05	1.94
18	.0403	1.62	1.64	1.83	1.73
19	.0359	1.44	1.46	1.63	1.54
20	.0320	1.28	1.30	1.45	1.37
21	.0285	1.14	1.16	1.29	1.22
22	.0253	1.02	1.03	1.15	1.08
23	.0226	.906	.918	1.02	.966
24	.0201	.807	.817	.911	.860
25	.0179	.718	.728	.811	.766
26	.0159	.640	.648	.722	.682
27	.0142	.570	.577	.643	.608
28	.0126	.507	.514	.573	.541
29	.0113	.452	.458	.510	.482
30	.0100	.402	.408	.454	.429
31	.0089	.358	.363	.404	.382
32	.0080	.319	.323	.360	.340
33	.0071	.284	.288	.321	.303
34	.0063	.253	.256	.286	.270
35	.0056	.225	.228	.254	.240

SIZE AND WEIGHT PER SHEET OF GENUINE IMPORTED RUSSIAN IRON.

Sizes 28× 56 Inches only.

Numbers.	Size.	Approximate Weight per Sheet.	Approximate Wire Gauge
No. 7	28×56 in.	$6\frac{1}{4}$ lbs.	No. 29
" 8	28×56 "	$7\frac{1}{4}$ "	" 28
" 9	28×56 "	8 "	" 27
" 10	28×56 "	9 "	" 26
" 11	28×56 "	10 "	" 25
" 12	28×56 "	$10\frac{3}{4}$ "	" $24\frac{1}{2}$
" 13	28×56 "	$11\frac{3}{4}$ "	" 24
" 14	28×56 "	$12\frac{1}{2}$ "	" $23\frac{1}{2}$
" 15	28×56 "	$13\frac{1}{2}$ "	" $22\frac{3}{8}$
" 16	28×56 "	$14\frac{2}{3}$ "	" $21\frac{1}{2}$

Average net weight per bundle, about 225 lbs.

WEIGHT OF METAL SHINGLES.

Metal shingles weigh from 80 to 90 pounds per square of 100 feet, depending on the shape of the shingle and the weight of the metal.

SIZE AND LENGTH OF TINNERS' NAILS.

$\frac{3}{4}$ inch long, made of No. 13 wire.
$\frac{7}{8}$ inch long, made of No. 12 wire.
1 inch long, made of No. 12 wire.
$1\frac{1}{4}$ inch long, made of No. 11 wire.
$1\frac{1}{2}$ inch long, made of No. 10 wire.
2 inch long, made of No. 9 wire.

PART IV.

GAS PIPING, ETC. RULES FOR GAS FITTING. SOIL AND VENT PIPES. NAMES, SIZES, ETC., OF SOIL PIPE FITTINGS. VARIOUS METHODS AND SHORT CUTS FOR PLUMBERS. RULES FOR PLUMBING.

Gas Piping, Etc.

The gas pipes in a building should be wrought iron or soft steel of standard make. The fittings should be galvanized, as the zinc coating makes the fittings more solid and durable. Each piece of pipe before being put in place should be looked or blown through to see if it is clear of any stoppage.

All joints should be made in red lead, and no gas-fitters' cement should be used in any joints except the caps on the outlets. In running a line of pipe it should run in as direct a line and with as few turns as possible. All pipes should be run so they will have a fall to the riser or starting-point, so that any water which may gather will run back to the main. In taking off branches or outlets from any run of pipe they should always be taken out at the side and all drop lights should be taken from a tee fitting in a short branch, and the branch extended about a foot beyond the tee and capped; this insures the drop to hang plumb.

Bracket lights should always be brought from the floor below, as gas should never be made to run down a pipe where it is possible to do otherwise, where convenient separate risers should be run to each floor and controlled by stopcocks in the cellar where they can be got at. When pipes cross wooden beams or joists, the pipes should be run across the top of the beams and the beams notched as little as possible, and not more than two feet from a bearing.

A short piece of pipe with a draw-off cock should be placed at the foot of each riser to catch and draw off any condensation.

All pipes for drops, chandeliers, etc., should be perfectly plumb, and all bracket outlets at right angles to the wall, so the fixture will hang true. A good way is to screw a short piece of pipe on the outlet and test for "true." Fig. 94 shows a handy pipe fastener now on the market, which clamps and holds the drop rigid.

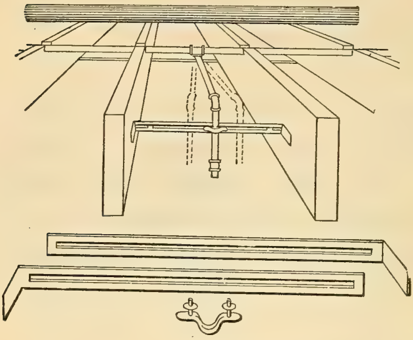


Fig. 94. Gas drop clamp.

Lines of gas pipes should never be placed under a tile or marble floor unless absolutely necessary, as it is too difficult to get at them in case of repairs.

Meters should always be placed at a convenient height for reading the dials, and when possible placed so the light from a window will throw light on the dials.

The following sizes of connections should be left for the meter:

3 light	$\frac{3}{4}$ in. diameter	60 light	2 in. diameter
5 light	$\frac{3}{4}$ in. diameter	100 light	2 in. diameter
10 light	$1\frac{1}{4}$ in. diameter	150 light	$2\frac{1}{2}$ in. diameter
20 light	$1\frac{1}{4}$ in. diameter	200 light	$2\frac{1}{2}$ in. diameter
30 light	$1\frac{1}{2}$ in. diameter	250 light	3 in. diameter
45 light	$1\frac{1}{2}$ in. diameter	300 light	4 in. diameter

When the pipes are all in place it is a good idea to take the plans and go over the entire building to see that outlets have been provided for at every point indicated on the drawings.

Then all outlets should be capped or plugged and the whole system tested with a good gauge (a mercury gauge is the best).

When air is pumped into a completed system of pipes until the gauge shows a pressure of about 12 inches of mercury (which is equal to about 6 pounds pressure per square inch) and stands or remains stationary for 15 minutes, it may be considered that the pipes are tight. If the mercury drops at the rate of 2 inches an hour there are leaks that should be found and stopped. Where possible it is best to test each floor of piping separate. After the test is

made, a good scheme is to leave the pressure on and loosen the cap on each outlet separately and notice if the pressure goes down as each one is loosened; this will show if the pipes are all clear, or if any of them contains any obstruction. The test on the pipes should be repeated just before the plastering is commenced, and again when it is finished.

The following table shows the size of pipes and number of burners which they will supply:

Greatest Number of Feet to be Run.	Size of Pipe.	Greatest Number of Burners to be Supplied.	Greatest Number of Feet to be Run.	Size of Pipe.	Greatest Number of Burners to be Supplied.
20 feet	$\frac{3}{8}$ inch	2	150 feet	$1\frac{1}{2}$ inches	70
30 "	$\frac{1}{2}$ "	4	200 "	2 "	140
50 "	$\frac{3}{4}$ "	15	300 "	$2\frac{1}{2}$ "	225
70 "	1 "	25	400 "	3 "	300
100 "	$1\frac{1}{4}$ inches	40	500 "	4 "	500

Computing the Pressure.—Pressures which have been measured in inches of water or mercury may be translated in pounds per square inch or foot by multiplying the reading by the following figures:

One inch of water at 62° equals 5.2 pounds per square foot.

One inch of water at 62° equals 0.0361 pound per square inch.

One inch of mercury at 62° equals 0.4897 pound per square inch.

Pressures per square inch or square foot may be converted into inches or feet of water, or inches of mercury, by multiplying the pressure by the following figures:

One pound per square foot equals 0.1923 inch of water.

One pound per square inch equals 27.7 inches of water at 62°.

One pound per square inch equals 2.042 inches of mercury at 62°.

Increase of Pressure.—The increase of pressure in each 10 feet of rise in pipes with gas of various densities is as follows:

Rise in pressure (ins. of water).........	0	.0147	.0293	.044	.058	.073	.088	.102
Density of gas......	1	.9	.8	.7	.6	.5	.4	.3

Example.—The pressure in the basement at the meter is 1.2 of water; what will be the pressure at the sixth story, 70 feet above, the density of the gas being .4?

Solution.—The table shows that the increase will be 0.088 inch for each 10 feet of rise, therefore 0.088×7 equals 0.616 inch increase. Then the pressure at the sixth story equals $1.2 + 0.616 = 1.816$.

CAPACITY OF GAS-PIPES UNDER A PRESSURE OF 10.4 LBS. PER SQUARE FOOT.

Diameter of Pipe in Inches.	Maximum Length in Feet.	Capacity per Hour.	
		Coal Gas, Cubic Feet.	Gasoline Gas, Cubic Feet.
$\frac{1}{4}$	6	10	....
$\frac{3}{8}$	20	15	10
$\frac{1}{2}$	30	30	20
$\frac{3}{4}$	50	100	75
1	70	175	125
$1\frac{1}{4}$	100	300	200
$1\frac{1}{2}$	150	500	350
2	200	1000	700
$2\frac{1}{2}$	300	1500	1100
3	450	2250	1500
4	600	3750	2500

Flow of Gas in Pipes.—If d = diameter of pipe in inches; Q = quantity of gas delivered in cubic feet per hour; l = length of pipe in yards; h = pressure in inches of water-column; s = specific gravity of the gas, air being one; then

$$Q = 1000\sqrt{\frac{d^5 h}{sl}}; \text{ (Molesworth);}$$

$$Q = 1350 d^2 \sqrt{\frac{dh}{sl}} \text{ (King's Treatise on Coal-gas);}$$

$$Q = 1290\sqrt{\frac{d^5 h}{d(s+l)}} \text{ (J. P. Gill, \textit{Am. Gas-light Jour.}, 1894).}$$

Mr. Gill's formula is said to be based on experimental data, and to make allowance for obstructions by tar, etc., that tend to check the flow of gas through the pipe.

An experiment made by Mr. Klegg, in London, on a 4-inch pipe 6 miles long gave a discharge that corresponds very closely with that computed by the use of Molesworth's formula.

The following formula for the flow of gases in pipes, together with coefficients for a wide range of pipe sizes, was submitted by Mr. L. P. Lowe of San Francisco, in the course of a paper on the subject presented to a meeting July, 1904, in that city of the Pacific Coast Gas Association. The formula is practically of the form printed herewith, and the values of the coefficients C are given in the accompanying table. Q stands for the number of cubic feet of gas delivered per minute at atmospheric pressure; C is the constant with different values for

$$2 = CR\sqrt{D^5 p \div 0.0761\ SRL}$$

different pipe sizes, owing to the difference in the frictional resistance, especially in pipes of small size; $R = (P + 14.7) \div 14.7$ where P is the terminal gauge pressure, so that R is the ratio of absolute terminal pressure to the atmospheric pressure; D is the

VALUES OF CONSTANT FOR DIFFERENT SIZES PIPE.

Diameter, Inches.	Constant.	Diameter, Inches.	Constant.
0.5	36.8	9	61.2
2.0	52.7	10	62.1
3.	56.1	14	62.3
4.	57.8	16	62.6
5.	58.4	18	62.7
6.	59.5	20	62.9
7.	60.1	22	63.2
8.	60.7	24	63.2

internal diameter of the pipe in inches; p is the difference between initial and terminal pressure in pounds per square inch; 0.0761 is the weight of 1 cu. ft. of air at atmospheric pressure; S is the specific gravity of the gas; and L, the length of the pipe in feet.

The formula is based on pipe lines constructed of wrought pipes joined with ordinary screw fittings, and contemplates straight runs without sharp, right angle bends. The author did not offer any rules for modifying the formula when there are any bends or valves in the pipe line, but cited a number of examples

indicating their effect. Having calculated the delivery of a mile of straight 4-in. piping under a pressure head of 10 lbs. per square inch, he said that to deliver the same quantity with a single sharp right angle bend would require 10.9 lbs. pressure, an increase of 9 per cent. With three bends, other conditions remaining the same, 11.3 lbs. pressure would have been required, an increase of 13 per cent. With long sweep fittings the increase of pressure would be much lessened.

SIZE OF PIPE TO SUPPLY GAS LOGS AND RANGES.*

Diam. of Pipe, Inches.	Maximum Length, Feet.	Maximum Number Lights.	Diam. of Pipe, Inches.	Maximum Length, Feet.	Maximum Number Lights.
½	100	1	1	100	4
¾	100	2	1¼	100	7

Size of Service Pipe. In running the service pipe from the front wall of a building to the meter the size of the pipe should be governed by the length of run.

Size of Pipe.	Greatest Length of Run.	Number of ¾ in. Outlets it will supply.
1 inch	70 feet	1 opening
1¼ inch	100 feet	3 openings
1½ inch	150 feet	5 openings
2 inch	200 feet	8 openings

* The number of gas logs and ranges in the third column of the table refers to sizes for which the consumption in any log or range does not exceed 35 cu. ft. per hour. The size of the piping for gas logs and ranges is for single lines run from or near the meter or source of supply for the specific purpose indicated.

When gas logs and ranges are supplied by branch pipes, or when any branch pipes are run from the main system of the building, the combined sectional areas of all pipe sections must exceed the sectional area of the main supply pipe sufficient to maintain the proper flow.

MAXIMUM SUPPLY OF GAS THROUGH PIPES IN CUBIC FEET PER HOUR, SPECIFIC GRAVITY BEING 0.45.

Formula, $Q = 1000\sqrt{d^5h \div sl}$. (Molesworth.)

LENGTH OF PIPE = 10 YARDS.

Diameter of Pipe in Inches.	Pressure by the Water-gauge in Inches.									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
$\frac{3}{8}$	13	18	22	26	29	31	34	36	38	41
$\frac{1}{2}$	26	37	46	53	59	64	70	74	79	83
$\frac{3}{4}$	73	103	126	145	162	187	192	205	218	230
1	149	211	258	298	333	365	394	422	447	471
$1\frac{1}{4}$	260	368	451	521	582	638	689	737	781	823
$1\frac{1}{2}$	411	581	711	821	918	1006	1082	1162	1232	1299
2	843	112	1460	1686	1886	2066	2231	2385	2530	2667

LENGTH OF PIPE = 100 YARDS.

Diameter of Pipe in Inches.	Pressure by the Water-gauge in Inches.										
	0.1	0.2	0.3	0.4	0.5	0.75	1.0	1.25	1.5	2.0	2.5
$\frac{1}{2}$	8	12	14	17	19	23	26	29	32	36	42
$\frac{3}{4}$	23	32	42	46	51	63	73	81	89	103	115
1	47	67	82	94	105	129	149	167	183	211	236
$1\frac{1}{4}$	82	116	143	165	184	225	260	291	319	368	412
$1\frac{1}{2}$	130	184	225	260	290	356	411	459	503	581	649
2	267	377	462	533	596	730	843	943	1033	1193	1333
$2\frac{1}{2}$	466	659	807	932	1042	1276	1473	1647	1804	2083	2329
3	735	1039	1270	1470	1643	2012	2323	2598	2846	3286	3674
$3\frac{1}{2}$	1080	1528	1871	2161	2416	2958	3416	3820	4184	4831	5402
4	1508	2133	2613	3017	3373	4131	4770	5333	5842	6746	7542

LENGTH OF PIPE = 1000 YARDS.

Diameter of Pipe in Inches.	Pressure by the Water-gauge in Inches.						
	0.5	0.75	1.0	1.5	2.0	2.5	3.0
1	33	41	47	58	67	75	82
$1\frac{1}{2}$	92	113	130	159	184	205	226
2	189	231	267	327	377	422	462
$2\frac{1}{2}$	329	403	466	571	659	737	807
3	520	636	735	900	1039	1162	1273
4	1067	1306	1508	1847	2133	2385	2613
5	1863	2282	2635	3227	3727	4167	4564
6	2939	3600	4157	5091	5879	6573	7200

MAXIMUM SUPPLY OF GAS THROUGH PIPES, ETC.—(*Continued*).

LENGTH OF PIPE = 5000 YARDS.

Diameter of Pipe in Inches.	Pressure by the Water-gauge in Inches.				
	1.0	1.5	2.0	2.5	3.0
2	119	146	169	189	207
3	329	402	465	520	569
4	675	826	955	1067	1168
5	1179	1443	1667	1863	2041
6	1859	2277	2629	2939	3220
7	2733	3347	3865	4321	4734
8	3816	4674	5397	6034	6610
9	5123	6274	7245	8100	8873
10	6667	8165	9428	10541	11547
12	10516	12880	14872	16628	18215

Where there is apt to be trouble from frost no pipe less than ¾ inch should be used, and in extremely cold climates the smallest size should not be less than 1 inch.

To provide for the resistance due to bends, one rule is to allow a pressure of 0.204 inch of water-column for each right-angled elbow.

AQUEOUS VAPOR CONTAINED IN 1000 CUBIC FEET OF GAS AT INDICATED TEMPERATURE.

Temp. Degrees.	Volume Aqueous Vapor.	Temp. Degrees.	Volume Aqueous Vapor.	Temp. Degrees.	Volume Aqueous Vapor.
40	9.33	54	15.33	68	24.06
41	9.73	55	15.86	69	24.83
42	10.13	56	16.40	70	25.66
43	10.53	57	16.93	71	26.53
44	10.93	58	17.53	72	27.40
45	11.33	59	18.10	73	28.30
46	11.73	60	18.66	74	29.23
47	12.13	61	19.23	75	30.20
48	12.53	62	19.80	76	31.20
49	12.93	63	20.50	77	32.20
50	13.33	64	21.20	78	33.23
51	13.80	65	21.90	79	34.23
52	14.26	66	22.60	80	35.33
53	14.80	67	23.30	81	36.43

SIZE, WEIGHT, ETC., OF STEEL OR WROUGHT IRON PIPE, NATIONAL TUBE COMPANY.

Black or Galvanized Standard Weight Pipe.

Diameter			Thickness.	Circumference.		Transverse Areas.			Nominal Weight per Foot. Pounds	Threads per Inch.
Nominal.	External.	Internal.		External.	Internal.	External.	Internal.	Metal.		
1/8	.405	.269	.068	1.272	.845	.1288	.0568	.0720	.241	27
1/4	.540	.364	.088	1.696	1.144	.2290	.1041	.1249	.42	18
3/8	.675	.493	.091	2.121	1.549	.3578	.1909	.1669	.559	18
1/2	.840	.622	.109	2.639	1.954	.5542	.3039	.2503	.837	14
3/4	1.050	.824	.113	3.299	2.589	.8659	.5333	.3326	1.115	14
1	1.315	1.047	.134	4.131	3.289	1.3581	.8609	.4972	1.668	11½
1¼	1.660	1.380	.140	5.215	4.335	2.1642	1.4957	.6685	2.244	"
1½	1.900	1.610	.145	5.969	5.058	2.8353	2.0358	.7995	2.678	"
2	2.375	2.067	.154	7.461	6.494	4.4301	3.3556	1.074	3.609	"
2½	2.875	2.467	.204	9.032	7.750	6.4918	4.7800	1.712	5.739	8
3	3.500	3.066	.217	10.996	9.632	9.6211	7.3827	2.238	7.536	"
3½	4.000	3.548	.226	12.566	11.146	12.566	9.886	2.680	9.001	"
4	4.500	4.026	.237	14.137	12.648	15.904	12.730	3.174	10.665	"
4½	5.000	4.508	.246	15.708	14.162	19.635	15.960	3.675	12.34	"
5	5.563	5.045	.259	17.477	15.849	24.306	19.985	4.321	14.502	"
6	6.625	6.065	.280	20.813	19.054	34.472	28.886	5.586	18.762	"
7	7.625	7.023	.301	23.955	22.063	45.664	38.743	6.921	23.271	"
8	8.625	7.981	.322	27.096	25.073	58.426	50.021	8.405	28.177	"
9	9.625	8.937	.344	30.238	28.076	72.760	62.722	10.04	33.701	"
10	10.750	10.018	.366	33.772	31.472	90.763	78.822	11.94	40.065	"
11	11.750	11.000	.375	36.913	34.558	108.43	95.034	13.40	45.95	"
12	12.750	12.000	.375	40.055	37.699	127.68	113.09	14.59	48.985	"

Allow variation in weight per foot of 5 per cent above and 5 per cent below. Cannot cut closer to length than 1/16 inch. Shipped threads and couplings unless otherwise ordered.

SIZE, WEIGHT, ETC., OF STEEL OR WROUGHT IRON PIPE, NATIONAL TUBE COMPANY.

Standard Extra Strong Pipe.

Diameter.			Thickness.	Circumference.		Transverse Areas.			Nominal Weight per Foot. Pounds.	Threads per Inch.
Nominal.	External.	Internal.		External.	Internal.	External.	Internal.	Metal.		
$\frac{1}{8}$	.405	.205	.100	1.272	.644	.129	.033	.096	.29	27
$\frac{1}{4}$	.540	.294	.123	1.696	.924	.229	.068	.161	54	18
$\frac{3}{8}$	.675	.421	.127	2.121	1.323	.358	.139	.219	.74	"
$\frac{1}{2}$	.840	.542	.149	2.639	1.703	.554	.231	.323	1.09	14
$\frac{3}{4}$	1.050	.736	.157	3.299	2.312	.866	.425	.441	1.39	"
1	1.315	.951	.182	4.131	2.988	1.358	.710	.648	2.17	$11\frac{1}{2}$
$1\frac{1}{4}$	1.660	1.272	.194	5.215	3.996	2.164	1.271	.893	3.00	"
$1\frac{1}{2}$	1.900	1.494	.203	5.969	4.694	2.835	1.753	1.082	3.63	"
2	2.375	1.933	.221	7.461	6.073	4.430	2.935	1.495	5.02	"
$2\frac{1}{2}$	2.875	2.315	.280	9.032	7.273	6.492	4.209	2.283	7.67	8
3	3.500	2.892	.304	10.996	9.086	9.621	6.569	3.052	10.25	"
$3\frac{1}{2}$	4.000	3.358	.321	12.566	10.549	12.566	8.856	3.710	12.47	"
4	4.500	3.818	.341	14.137	11.995	15.904	11.449	4.455	14.97	"
$4\frac{1}{2}$	5.000	4.280	.360	15.708	13.446	19.635	14.387	5.248	18.22	"
5	5.563	4.813	.375	17.477	15.120	24.306	18.193	6.113	20.54	"
6	6.625	5.751	.437	20.813	18.067	34.472	25.976	8.496	28.58	"
7	7.625	6.625	.500	23.955	20.813	45.664	34.472	11.192	37.67	"
8	8.625	7.625	.500	27.096	23.955	58.426	45.664	12.762	43.00	"
9	9.625	8.625	.500	30.238	27.096	72.760	58.426	14.334	48.25	"
10	10.750	9.750	.500	33.772	30.631	90.763	74.662	16.101	54.25	"
12	12.750	11.750	.500	40.055	36.914	127.68	108.43	19.25	65.00	"

Allow variation in weight per foot of 5 per cent above and 5 per cent below standard. Cannot cut to length closer than $\frac{1}{16}$ inch. Shipped plain ends unless otherwise ordered. Where extra-strong pipe is ordered with threads and couplings, our regular line-pipe couplings will be furnished unless otherwise specified.

SIZE, WEIGHT, ETC., OF STEEL OR WROUGHT IRON PIPE, NATIONAL TUBE COMPANY.

STANDARD DOUBLE EXTRA STRONG PIPE.

Diameter.			Thickness.	Circumference.		Transverse Areas.			Nominal Weight per Foot. Pounds.	Threads per Inch.
Nominal.	External.	Internal.		External.	Internal.	External.	Internal.	Metal.		
½	.840	.244	.298	2.639	.767	.554	.047	.507	1.7	14
¾	1.050	.422	.314	3.299	1.326	.866	.140	.726	2.44	14
1	1.315	.587	.364	4.131	1.844	1.358	.271	1.087	3.65	11½
1¼	1.660	.885	.388	5.215	2.780	2.164	.615	1.549	5.2	"
1½	1.900	1.088	.406	5.969	3.418	2.835	.930	1.905	6.4	"
2	2.375	1.491	.442	7.461	4.684	4.430	1.744	2.686	9.02	"
2½	2.875	1.755	.560	9.032	5.514	6.492	2.419	4.073	13.68	8
3	3.500	2.284	.608	10.996	7.176	9.621	4.097	5.524	18.56	"
3½	4.000	2.716	.642	12.566	8.533	12.566	5.794	6.772	22.75	"
4	4.500	3.136	.682	14.137	9.852	15.904	7.724	8.180	27.48	"
4½	5.000	3.564	.718	15.708	11.197	19.635	9.976	9.659	32.53	"
5	5.563	4.063	.750	17.477	12.764	24.306	12.965	11.341	38.12	"
6	6.625	4.875	.875	20.813	15.315	34.472	18.665	15.807	53.11	"
7	7.625	5.875	.875	23.955	18.457	45.664	27.109	18.555	62.38	"
8	8.625	6.875	.875	27.096	21.598	58.426	37.122	21.304	71.62	"

Allow variation of 5 per cent above and 5 per cent below standard in weight per foot. Cannot cut to length closer than $\frac{1}{16}$ inch. Shipped plain ends unless otherwise ordered.

STANDARD DIMENSIONS OF COUPLINGS FOR STEAM, GAS, AND WATER PIPE.

Black and Galvanized.

Size of Pipe. Nominal Inside Diameter.	Nominal Inside Diameter of Coupling.	Nominal Outside Diameter of Coupling.	Nominal Length of Coupling.	Thread per Inch of Screw.	Average Weight of Coupling in Pounds.
Inches.	Inches.	Inches.	Inches.		
$\frac{1}{8}$	$\frac{11}{32}$	$\frac{5}{8}$	$\frac{7}{8}$	27	.035
$\frac{1}{4}$	$\frac{15}{32}$	$\frac{11}{16}$	$\frac{15}{16}$	18	.050
$\frac{3}{8}$	$\frac{37}{64}$	$\frac{7}{8}$	$1\frac{1}{8}$	18	.080
$\frac{1}{2}$	$\frac{23}{32}$	$1\frac{1}{32}$	$1\frac{3}{8}$	14	.14
$\frac{3}{4}$	$\frac{63}{64}$	$1\frac{5}{16}$	$1\frac{5}{8}$	14	.25
1	$1\frac{11}{64}$	$1\frac{21}{32}$	$1\frac{7}{8}$	$11\frac{1}{2}$	.42
$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{8}$	$11\frac{1}{2}$	.63
$1\frac{1}{2}$	$1\frac{3}{4}$	$2\frac{1}{4}$	$2\frac{3}{8}$	$11\frac{1}{2}$	.86
2	$2\frac{7}{32}$	$2\frac{25}{32}$	$2\frac{5}{8}$	$11\frac{1}{2}$	1.38
$2\frac{1}{2}$	$2\frac{21}{32}$	$3\frac{9}{32}$	$2\frac{7}{8}$	8	1.90
3	$3\frac{1}{4}$	$3\frac{31}{32}$	$3\frac{1}{8}$	8	2.67
$3\frac{1}{2}$	$3\frac{25}{32}$	$4\frac{9}{16}$	$3\frac{5}{8}$	8	3.90
4	$4\frac{17}{64}$	$5\frac{1}{16}$	$3\frac{5}{8}$	8	4.40
$4\frac{1}{2}$	$4\frac{3}{4}$	$5\frac{17}{32}$	$3\frac{5}{8}$	8	4.70
5	$5\frac{9}{32}$	$6\frac{1}{4}$	$4\frac{1}{8}$	8	8.50
6	$6\frac{11}{32}$	$7\frac{9}{32}$	$4\frac{1}{8}$	8	9.70
7	$7\frac{3}{8}$	$8\frac{9}{32}$	$4\frac{1}{8}$	8	11.10
8	$8\frac{3}{8}$	$9\frac{1}{4}$	$4\frac{5}{8}$	8	13.60
9	$9\frac{7}{16}$	$10\frac{5}{16}$	$5\frac{1}{8}$	8	17.40
10	$10\frac{7}{16}$	$11\frac{5}{8}$	$6\frac{1}{8}$	8	31.10
11	$11\frac{15}{32}$	$12\frac{21}{32}$	$6\frac{1}{8}$	8	33.20
12	$12\frac{7}{16}$	$13\frac{7}{8}$	$6\frac{1}{8}$	8	44.20
13	$13\frac{11}{16}$	$15\frac{3}{16}$	$6\frac{3}{16}$	8	49.20
14	$14\frac{23}{32}$	$16\frac{3}{8}$	$6\frac{3}{16}$	8	61.00
15	$15\frac{11}{16}$	$17\frac{13}{32}$	$6\frac{3}{16}$	8	64.00

How Steel and Wrought-iron Pipes are Made.[1]—Lap-welding.—The plate for the larger sizes of pipe is first laid upon a travelling-table and the edges scarfed or bevelled. It is then heated in a bending furnace and rolled up into pipe form with the scarfed edges overlapping. The plates for the smaller sizes are formed up by being drawn through the die shown in the accompanying illustration. This consists of a stout cast-iron bending die the front half of which next the furnace door is flared out to receive the plate. Inside the die is a mandrel of the shape shown in the smaller engraving, whose rear portion is of about the size of the finished pipe. As the plate is pushed out of the furnace it is drawn by a pair of tongs through the die the flaring sides of which curve the plate until its edges meet and lap as they pass through the tubular end of the die. The plates, now bent up into form and known as skelp, are heated in a gas-fired welding furnace, and when they have reached a welding heat the skelp is pushed through the door at the back of the furnace into the welding-rolls, which are located just outside the door. The rolls, which are concave, are curved to the desired radius, and between them, held in position by a long bar, is a "ball," or mandrel, of the same diameter as the inside of the pipe. As the skelp passes through the rolls, its lapping edges are squeezed together between the rolls and the mandrel and a perfect weld is made. Each piece of pipe is carefully examined and all doubtful welds are rejected. The rough pipe then goes through the sizing rolls, in which it is brought to the exact diameter. Then it passes to the cross-straightening rolls the axes of which are inclined at an angle, as shown in the accompanying illustration. By this time it is perfectly true and straight, and to prevent it from warping as it cools, it is rolled and conveyed on a cooling-table to a straightening-machine, where it receives its final straightening in dies controlled by hydraulic pressure. The ends are then cut off, and after being threaded and the coupling put on, the pipe is tested in a hydraulic testing-machine, the smaller sizes at from 600 to 1500 pounds, the larger at from 500 to 750 pounds to the square inch. For oil-well tubing the tests run as high as 2500 pounds to the square inch.

Butt-welding.—The smaller sizes of pipes are butt-welded. The plates, which are not scarfed as in the larger pipe, are

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[1] *Scientific American.*

heated in the furnace, and when raised to a welding heat are drawn through a bell-shaped die the diameter of which is a little less than that of the skelp. The pressure thus induced is sufficient to squeeze the edges together and form the plate into a perfectly welded pipe.

WEIGHTS OF CAST-IRON PIPE IN POUNDS.

Standard Water-pipe.

Lbs. Lead per Joint.	Ounces Jute per Joint.	Size Pipe.	Thickness.	Weight per Foot with Bell.	Weight per Length with Bell.	Weight of Bell.
3	2.8	3″	$\frac{15}{32}''$	17	204	12
5.5	3.5	4″	$\frac{15}{32}''$	22	264	12
8	5.0	6″	$\frac{16}{32}''$	34	408	24
11	7.0	8″	$\frac{17}{32}''$	47	564	36
14	8.5	10″	$\frac{16}{32}''$	64	768	48
18	11.0	12″	$\frac{16}{32}''$	82	984	60
21	13.0	14″	$\frac{11}{16}''$	105	1260	72
24	15.0	16″	$\frac{3}{4}''$	133	1596	108
27	16.0	18″	$\frac{13}{16}''$	160	1920	120
31	20.0	20″	$\frac{7}{8}''$	190	2280	144
36	24.0	24″	1″	260	3120	180
50	33.0	30″	$1\frac{1}{8}''$	360	4320	204
76	48.0	36″	$1\frac{1}{4}''$	488	5856	360
95	58.0	42″	$1\frac{3}{8}''$	625	7500	468
112	70.0	48″	$1\frac{9}{16}''$	830	9960	648
170	100.0	60″	$1\frac{7}{8}''$	1220	14640	960

Standard Gas-pipe.

Lbs. Lead per Joint.	Ounces Jute per Joint.	Size Pipe.	Thickness.	Weight per Foot with Bell.	Weight per Length with Bell.	Weight of Bell.
3	2.8	3″	$\frac{25}{64}''$	14	168	12
5.5	3.5	4″	$\frac{13}{32}''$	19	228	12
8	5.0	6″	$\frac{7}{16}''$	30.5	366	18
11	7.0	8″	$\frac{15}{32}''$	41	492	24
14	8.5	10″	$\frac{1}{2}''$	56	672	48
18	11.0	12″	$\frac{35}{64}''$	74	888	60
21	13.0	14″	$\frac{19}{32}''$	92	1104	72
24	15.0	16″	$\frac{41}{64}''$	112	1344	96
27	16.0	18″	$\frac{11}{16}''$	133	1596	108
31	20.0	20″	$\frac{47}{64}''$	159	1908	120
36	24.0	24″	$\frac{51}{64}''$	205	2460	132
50	33.0	30″	$\frac{55}{64}''$	275	3300	168
76	48.0	36″	$\frac{61}{64}''$	368	4416	304

The above tables show the weights which have been adopted by the United States Cast Iron Pipe and Foundry Company as standard weights for water- and gas-pipe respectively for ordinary service.

LIST OF STANDARD CAST IRON SPECIALS.

(Approximate weight.)

Crosses.

Size in In.	Wt. in Lbs.
2	40
3	110
3×2	90
4	140
4×3	114
4×2	90
6	200
6×4	160
6×3	160
8	330
8×6	280
8×4	265
8×3	225
10	595
10×8	415
10×6	430
10×4	390
10×3	370
12	740
12×10	650
12×8	620
12×6	540
12×4	525
12×3	495
14×10	750
14×8	625
14×6	570
16	1100
16×14	1070
16×12	1000
16×10	1010
16×8	825
16×6	700
16×4	690
18	1560
20	1790
20×12	1370
20×10	1225
20×8	1335
20×6	1000
20×4	1000
24	2400
24×20	2020
24×6	1340
30×20	2635
30×12	2250
30×8	1995

Tees.

Size in In.	Wt. in Lbs.
2	28
3	85
3×2	76
4	110
4×3	120
4×2	87
6	170
6×4	145
6×3	145
6×2	75
8	290
8×6	280
8×4	220
8×3	220
10	390
10×8	345
10×6	370
10×4	350
10×3	330
12	600
12×10	555
12×8	530
12×6	525
12×4	550
14×12	650
14×10	650
14×8	575
14×6	545
14×4	525
14×3	490
16	790
16×14	850
16×12	850
16×10	825
16×8	755
16×6	680
16×4	655
18	1235
20	1475
20×16	1115
20×12	1025
20×10	1090
20×8	1070
20×6	875
20×4	845
24×10	1465
24	2000
24×20	1730

Tees.

Size in In.	Wt. in Lbs.
24×12	1425
24×8	1375
24×6	1450
30	3025
30×24	2640
30×20	2380
30×12	2035
30×10	2050
30×6	1825
36	5140
36×30	4200
36×12	4050

45° Branch Pipes.

Size in In.	Wt. in Lbs.
3	90
4	125
6	205
6×6×4	145
8	330
8×6	330
24	2765
24×24×20	2145
30	4170
36	10300

Sleeves.

Size in In.	Wt. in Lbs.
2	10
3	30
4	45
6	100
8	120
10	140
12	190
14	208
16	350
18	340
20	400
24	710
30	965
36	1200

LIST OF STANDARD CAST IRON SPECIALS. — *(Continued.)*

90° Elbows.

Size in In.	Wt. in Lbs.
2	14
3	34
4	55
6	120
8	150
10	260
12	370
14	450
16	660
18	850
20	900
24	1400
30	3000

⅛ or 45° Bends.

Size in In.	Wt. in Lbs.
3	30
4	70
6	95
8	150
10	200
12	290
16	510
18	580
20	780
24	1425
30	2000

1/16 or 22½° Bends.

Size in In.	Wt. in Lbs.
4	65
6	150
8	155
10	205
12	260
16	450
24	1280
30	2000

Reducers.

Size in In.	Wt. in Lbs.
3×2	35
4×3	45
4×2	40
6×4	95
6×3	70
8×6	126
8×4	116
8×3	116
10×8	200
10×6	180
10×4	160
12×10	320
12×8	300
12×6	250
12×4	250
14×12	475
14×10	400
14×8	390
14×6	285
16×12	475
16×10	435
20×16	690
20×14	575
20×12	540
20×8	400
24×20	860
30×24	1305
30×18	1385
36×30	1730

Angle Reducers for Gas.

Size in In.	Wt. in Lbs.
6×4	95
6×3	70

S Pipes.

Size in In.	Wt. in Lbs.
4	105
6	190

Plugs.

Size in In.	Wt. in Lbs.
2	3
3	10
4	10
6	15
8	30
10	46
12	66
14	90
16	100
18	130
20	150
24	185
30	370

Caps.

Size in In.	Wt. in Lbs.
3	20
4	25
6	60
8	75
10	100
12	120
16	265

Drip-boxes.

Size in In.	Wt. in Lbs.
4	295
6	330
8	375
10	875
20	1420

WEIGHT OF UNDERGROUND PIPES.

Adopted by the National Fire Protective Association, May 23, 1905.

Weights to be not less than those specified where the normal pressures do not exceed 125 pounds. Where the normal pressures are in excess of 125 pounds, heavier piping should be used. Weights given include sockets.

Size of pipe in inches	4	6	8	10	12	14	16
Weight per foot in pounds...	19	32	48	67	87	109	133

SIZE, WEIGHT, ETC., OF FLANGED CAST IRON PIPE — GAS AND WATER WEIGHT.

Size of Pipe.	Thickness of Pipe.	Diameter of Pipe.	Thickness of Flange.	Diameter of Bolt Circle.	No. and Size of Holes.	Size of Bolts.	Length of Bolts.	Estimated Weight per Foot.	Estimated Weight, 12 Ft. Length.
4	$\frac{3}{8}$	9	$\frac{15}{16}$	$7\frac{1}{2}$	4—$\frac{7}{8}$	$\frac{3}{4}$	$2\frac{3}{4}$	17	204
6	$\frac{7}{16}$	11	1	$9\frac{1}{2}$	8—$\frac{7}{8}$	$\frac{3}{4}$	3	30	360
8	$\frac{7}{16}$	$13\frac{1}{2}$	$1\frac{1}{8}$	$11\frac{3}{4}$	8—$\frac{7}{8}$	$\frac{3}{4}$	$3\frac{1}{2}$	40	480
10	$\frac{7}{16}$	16	$1\frac{3}{16}$	$14\frac{1}{4}$	12—1	$\frac{7}{8}$	$3\frac{5}{8}$	50	600
12	$\frac{1}{2}$	19	$1\frac{1}{4}$	17	12—1	$\frac{7}{8}$	$3\frac{3}{4}$	70	840
14	$\frac{9}{16}$	21	$1\frac{3}{8}$	$18\frac{3}{4}$	12—$1\frac{1}{8}$	1	$4\frac{1}{4}$	83	1000
16	$\frac{9}{16}$	$23\frac{1}{2}$	$1\frac{7}{16}$	$21\frac{1}{4}$	16—$1\frac{1}{8}$	1	$4\frac{1}{4}$	100	1200
18	$\frac{11}{11}$	25	$1\frac{9}{16}$	$22\frac{3}{4}$	16—$1\frac{1}{4}$	$1\frac{1}{8}$	$4\frac{3}{4}$	133	1600
20	$\frac{11}{16}$	$27\frac{1}{2}$	$1\frac{11}{16}$	25	20—$1\frac{1}{4}$	$1\frac{1}{8}$	5	150	1800
24	$\frac{3}{4}$	32	$1\frac{7}{8}$	$29\frac{1}{2}$	20—$1\frac{3}{8}$	$1\frac{1}{4}$	$5\frac{1}{2}$	183	2200
30	$\frac{7}{8}$	$38\frac{3}{4}$	$2\frac{1}{8}$	36	28—$1\frac{1}{2}$	$1\frac{3}{8}$	$6\frac{1}{4}$	275	3300
36	1	$45\frac{3}{4}$	$2\frac{3}{8}$	$42\frac{3}{4}$	32—$1\frac{1}{2}$	$1\frac{3}{8}$	$6\frac{1}{4}$	392	4708
42	1	$52\frac{3}{4}$	$2\frac{5}{8}$	$49\frac{1}{2}$	36—$1\frac{5}{8}$	$1\frac{1}{2}$	$7\frac{1}{2}$	497	5962
48	$1\frac{1}{4}$	$59\frac{1}{2}$	$2\frac{3}{8}$	56	44—$1\frac{5}{8}$	$1\frac{1}{2}$	$7\frac{3}{4}$	698	8374

Size of Pipe.	Thickness of Pipe.	Diameter of Pipe.	Thickness of Flange.	Diameter of Bolt Circle.	No. and Size of Holes.	Size of Bolts.	Length of Bolts.	Estimated Weight per Foot.	Estimated Weight, 12 Ft. Length.
4	$\frac{7}{16}$	9	$\frac{15}{16}$	$7\frac{1}{2}$	4—$\frac{7}{8}$	$\frac{3}{4}$	$2\frac{3}{4}$	22	264
6	$\frac{1}{2}$	11	1	$9\frac{1}{2}$	8—$\frac{7}{8}$	$\frac{3}{4}$	3	33	396
8	$\frac{9}{16}$	$13\frac{1}{2}$	$1\frac{1}{8}$	$11\frac{3}{4}$	8—$\frac{7}{8}$	$\frac{3}{4}$	$3\frac{1}{2}$	45	540
10	$\frac{5}{8}$	16	$1\frac{3}{16}$	$14\frac{1}{4}$	12—1	$\frac{7}{8}$	$3\frac{5}{8}$	60	720
12	$\frac{5}{8}$	19	$1\frac{1}{4}$	17	12—1	$\frac{7}{8}$	$3\frac{3}{4}$	80	960
14	$\frac{3}{4}$	21	$1\frac{3}{8}$	$18\frac{3}{4}$	12—$1\frac{1}{8}$	1	$4\frac{1}{4}$	117	1400
16	$\frac{3}{4}$	$23\frac{1}{2}$	$1\frac{7}{16}$	$21\frac{1}{4}$	16—$1\frac{1}{8}$	1	$4\frac{1}{4}$	125	1500
18	$\frac{7}{8}$	25	$1\frac{9}{16}$	$22\frac{3}{4}$	16—$1\frac{1}{4}$	$1\frac{1}{8}$	$4\frac{3}{4}$	167	2000
20	$\frac{15}{16}$	$27\frac{1}{2}$	$1\frac{11}{16}$	25	20—$1\frac{1}{4}$	$1\frac{1}{8}$	5	200	2400
24	1	32	$1\frac{7}{8}$	$29\frac{1}{2}$	20—$1\frac{3}{8}$	$1\frac{1}{4}$	$5\frac{1}{2}$	250	3000
30	$1\frac{1}{8}$	$38\frac{3}{4}$	$2\frac{1}{8}$	36	28—$1\frac{1}{2}$	$1\frac{3}{8}$	$6\frac{1}{4}$	350	4200
36	$1\frac{3}{8}$	$45\frac{3}{4}$	$2\frac{3}{8}$	$42\frac{3}{4}$	32—$1\frac{1}{2}$	$1\frac{3}{8}$	$6\frac{1}{4}$	475	5700
42	$1\frac{3}{8}$	$52\frac{3}{4}$	$2\frac{5}{8}$	$49\frac{1}{2}$	36—$1\frac{5}{8}$	$1\frac{1}{2}$	$7\frac{1}{2}$	600	7200
48	$1\frac{1}{2}$	$59\frac{1}{2}$	$2\frac{3}{4}$	56	44—$1\frac{5}{8}$	$1\frac{1}{2}$	$7\frac{3}{4}$	775	9300

FLANGED CAST IRON PIPE — HEAVY WEIGHT.

Size of Pipe.	Thickness of Pipe.	Diameter of Pipe.	Thickness of Flange.	Diameter of Bolt Circle.	No. and Size of Holes.	Size of Bolts.	Length of Bolts.	Estimated Weight per Foot.	Estimated Weight 12 Ft. Length.
4	½	9	15/16	7½	4— ⅞	¾	2¾	24	285
6	9/16	11	1	9½	8— ⅞	¾	3	39	465
8	⅝	13½	1⅛	11¾	8— ⅞	¾	3½	57	680
10	¾	16	1 3/16	14¼	12—1	⅞	3⅝	84	1010
12	13/16	19	1¼	17	12—1	⅞	3¾	109	1304
14	⅞	21	1⅜	18¾	12—1⅛	1	4¼	137	1642
16	1	23½	1 7/16	21¼	16—1⅛	1	4¼	178	2137
18	1 1/16	25	1 9/16	22¾	16—1¼	1⅛	4¾	209	2503
20	1⅛	27½	1 11/16	25	20—1¼	1⅛	5	250	2980
24	1¼	32	1⅞	29½	20—1⅜	1¼	5½	330	3965
30	1½	38¾	2⅛	36	28—1½	1⅜	6¼	495	5937
36	1¾	45¾	2⅜	42¾	32—1½	1⅜	6¼	693	8316
42	2	52¾	2⅝	49½	36—1⅝	1½	7½	924	11081
48	2¼	59½	2¾	56	44—1⅝	1½	7¾	1182	14179

The Meaning of Trade Terms as Applied to Wrought Pipe.

Wrought Iron Pipe. — This term is now used indiscriminately to designate all butt or lap welded pipe, whether made of iron or steel.

Merchant Pipe. — This term is used to indicate the regular wrought pipe of the market, and such orders are usually filled by the shipment of soft steel pipe. The weight of merchant pipe will usually be found to be about five per cent less than card weight, in sizes ⅛ inch to six inch, inclusive, and about ten per cent less than card weight, in sizes seven inch to twelve inch, inclusive.

Full Weight Pipe. — This term is used where pipe is required of about card weight. All such pipe is made from plates which are expected to produce pipe of card weight, and most of such pipe will run full card to a little above card, but owing to exigencies of manufacture, some lengths may be below card, but never more than five per cent.

Large O. D. Pipe. — A term used to designate all pipe larger than twelve inch. Pipe twelve inch and smaller is known by the nominal internal diameter, but all larger sizes by their external diameter, so that "fourteen-inch pipe," if three-eighths inch thick, is thirteen and one-fourth inch inside, and "twenty inch pipe" of same thickness is nineteen and one-fourth inch inside.

The terms "Merchant," or "Standard pipe," are not applicable to "Large O. D. pipe," as these are made in various weights, and should properly be ordered by the thickness of the metal.

When ordering large pipe threaded, it must be remembered that one-fourth inch metal is too light to thread, five sixteenths being minimum thickness.

Orders received by manufacturers for large outside diameter pipe, wherein the thickness of metal is not specified, are filled as follows:

Fourteen, fifteen, and sixteen inch, O. D., five-sixteenths or three-eighths inch metal.

Larger sizes three-eighths inch metal.

This pipe is shipped with plain ends, unless definitely ordered "threaded."

Extra Strong Pipe. — This term designates a heavy pipe, from one-eighth to eight inches only, made of either puddled wrought iron or soft steel. Unless directed to the contrary, manufacturers usually ship steel pipe. If wrought iron pipe is required, use the term, "Strictly Wrought Iron Extra Strong Pipe." Extra strong pipe is always shipped with plain ends and without couplings, unless instructions to thread and couple are given, for which there is an extra charge.

This term, when applied to pipe larger than eight inch, is somewhat indefinite, as nine, ten, and twelve inch is made both seven-sixteenths and one-half inch thick. These sizes are usually carried in stock, one-half inch thick, and always furnished that thickness on open orders.

Double extra Strong Pipe. — This pipe is approximately twice as heavy as extra strong, and is made from one-half to eight inches, in both iron and steel. It is difficult, however, to find any quantity in "Strictly Wrought Iron," and stock is usually soft steel. This pipe is shipped with plain ends, without couplings, unless ordered to thread and couple, for which there is an extra charge.

Cement Joints for Gas Mains.*

Cement joints for gas mains were adopted by the Laclede Gas Light Company of St. Louis, Mo., in 1904. Subsequently the company was ordered by the Director of Public Works to discontinue the use of cement for joints. The reason given for this order was that the joints would undoubtedly leak in the future, necessitating disturbance of the streets for repairs. The company at once addressed circulars to sixty gas companies asking for their experience with cement joints and the attitude of their respective city authorities on the subject. A total of fifty-two replies were received. These replies, together with the results of numerous tests of cement joints in St. Louis, tables comparing the cost of cement and lead joints and a general discussion of the subject, were submitted to the convention of the Western Gas Association at Chicago last May, in a paper by Mr. Jacob D. von Maur, † C. E.

The points brought out by the circulars sent to the various companies are summarized by Mr. von Maur as follows:

(1) In general, those answers which are unfavorable to the use of cement come from cities where cement has never been tried very extensively.

(2) There seems to be a prejudice against the use of cement in the business sections of the very large cities.

(3) In a number of cases cement joints were used to a very limited extent with very good success, yet for some unexplainable reason its use was not continued.

(4) In every case, with one exception, Portland cement was used, and in the exception noted Rosendale cement was used.

(5) There is a difference of opinion as to whether it is necessary to use the foreign or more expensive brands of Portland cement or domestic cements.

(6) There is a very wide difference of opinion as to whether provision should be made for expansion or not, but in every case where provision was made at all it was done by inserting lead joints at stated intervals.

(7) It seems to be the generally accepted opinion that cement

* Engineering News.

† Superintendent of the Street Department of the Laclede Gas Light Co., St. Louis, Mo. The paper was a long one. It may be found in full in the "Progressive Age" of June 15, 1905, where it fills about a dozen pages.

should not be used in soft places or in any place where there is likely to be a settlement of the pipe or where the pipe is subjected to vibration.

(8) It is very important to note that in almost every case the tests applied to pipe laid with cement joints are many times greater than the tests applied to pipe laid with lead joints.

(9) In only one case was an objection made by the city officials to the use of cement joints, and this objection was removed as soon as the value of the cement joint was demonstrated; so that at present we have no record of an objection on the part of the city officials to the use of cement in making up joints.

(10) In no case has the leakage increased by the use of cement, and in nearly every case the leakage has decreased.

Mr. von Maur emphasizes, at another point in his paper, the importance of laying gas pipe on a solid foundation, without which, he says, it is useless to try to prevent leakages. He suggests laying a board or plank beneath each end of each length of pipe, the board being laid flatwise at right angles to the pipe and being embedded to its own depth in the earth. Of course holes are dug for the pipe bells.

Nearly a third of the cities were not using cement at all, but of those a few proposed to do so soon.

The following cities were using cement for all or nearly all joints: Atlanta, Ga.; Bridgeport, Conn.; Camden, N. J. (for all low-pressure mains; do, same company, for Trenton and for numerous small towns); Chester, Pa. (also coating all wrought iron pipe with cement as a precaution against electrolysis); Danbury, Conn.; Derby, Conn.; Des Moines, Ia.; Fall River, Mass.; Grand Rapids, Mich.; Houston, Tex.; Lowell, Mass.; Mt. Vernon, N. Y.; New Orleans, La.; Paterson, N. J.; Philadelphia, Pa.; Pittsburg, Pa.; Reading, Pa.; St. Augustine, Fla.; Savannah, Ga.; Scranton, Pa.

The report from Chicago stated that a 16-inch main was laid with cement joints in 1862 and, so far as known, has given no trouble from leakage. In a number of cities cement joints have been used for 40 to 50 years.

Tests of cement joints in various sized mains at St. Louis were as a rule very favorable as to tightness.

The approximate saving in using cement instead of lead was given by Mr. von Maur, as shown by the accompanying table, the columns of larger figures being for heavier lead.

APPROXIMATE SAVING PER MILE OF GAS MAIN BY USING CEMENT INSTEAD OF LEAD JOINTS.

Diameter, Inches.		
4	$170.00	$114.80
6	218.00	129.80
8	319.00	165.00
10	398.00	244.20
12	490.00	337.92
16	660.00	554.40
20	834.00	822.80
24	1,249.00	1,137.08
30	1,632.00	1,485.00

C. P. Clark of Pittsburg uncovered some cement joints in an old gas main that had been used for gas from 1876 to 1903. In 1906 when the pipe was dug up the joints were found firm and solid, and there was no sign of corrosion of the pipe at any of the joints.

Rules for Gas Fitting.

The following rules for gas fitting are taken from the Cleveland Ohio Building Code:

Gas Fitting. Sec. 1. Gas Mains and Meters. — All gas mains entering any building shall be thoroughly cemented into the wall and shall have a shut-off near the curb line. Gas meters shall not be placed underneath any stairway or in any clothes or storage closet or in the dead space between the floors under show windows, and when located in any cellar or basement such location shall not be in any fuel or furnace room, but they shall be placed close to the front wall at least four (4) feet above the floor and as near a window as possible, with an unobstructed passageway leading thereto.

Sec. 2. Meters of Different Gases. — When different kinds of gases, either natural or artificial, or both, or electric wires, are used in the same building, the meters and shut-offs thereto within the building shall be placed as far as possible from each other, and if nearer than five (5) feet, there shall be a brick wall or a fireproof partition between them. Each gas system shall be separately and independently piped to its respective outlets,

and when it is desired to change from one system to another, the change shall be made at the meter; interconnecting pipe or by-passes shall not be used, provided that where two (2) gas systems have independent service pipes run from the meters to any furnace, heater, range or other outlet, the inter-connection may be made near the outlet with a positive three (3) way gas stopcock.

SEC. 3. PLANS OF GAS METERS AND SHUT-OFFS. — All meters, mains, and shut-offs within a building shall be located in an accessible, unobstructed, natural lighted place in the basement, if possible, and when the location of same in the basement is impracticable, they shall be grouped on their respective floors for all floors above the first, and the plans of such locations in buildings of the first, second and third grades shall be placed on file in the Department of Buildings for the use of the fire department. All plans shall show all outlets with the number of burners attached.

SEC. 4. BURNERS AND FIRES. — The term "burner" shall apply to any single gas outlet consuming not less than six (6) or more than ten (10) cubic feet per hour, and the term "fire" to any single outlet consuming from fifty (50) to and not exceeding seventy-five (75) cubic feet per hour.

SEC. 5. SIZES OF PIPE. — The size of pipe used for illuminating purposes shall not be less, nor the length greater, to the number of burners stated, than those specified in the following table, except that if the number of burners is not more than half the stated maximum, the length of run may be increased one-half:

Size of Pipe.	Greatest Length Allowed.	Greatest No. of Burners.
$\frac{3}{8}$ inch	10 feet	2
$\frac{1}{2}$ inch	30 feet	6
$\frac{3}{4}$ inch	60 feet	20
1 inch	80 feet	35
$1\frac{1}{4}$ inches	120 feet	60
$1\frac{1}{2}$ inches	160 feet	100
2 inches	200 feet	200
$2\frac{1}{2}$ inches	300 feet	300
3 inches	450 feet	450
4 inches	600 feet	750

But no riser from a meter shall be less than a three-quarter ($\frac{3}{4}$)-inch pipe.

In applying the above table, the number of burners to outlets in various locations shall be estimated as follows:

Parlor ceiling outlet	4 burners
Dining room ceiling outlet	4 burners
Bedroom ceiling outlet	3 burners
Kitchen ceiling outlet	1 burner
Bracket and newel post outlets	1 burner
Hall, pantry, wash room and bath room ceiling outlets	1 burner

An outlet for a gas range or water heater or a gas log or grate shall be counted as equivalent to and not less than six (6) burners, and all gas ranges and heaters shall have a straightway valve on the service pipe.

Smaller pipe than half-inch ($\frac{1}{2}$) shall not be used for kitchen outlets in ceilings.

Sec. 6. Quality of Pipe. — The pipe shall be of the best quality of wrought iron or steel pipe, with galvanized malleable iron fittings, and joints shall be made with white lead, preferably applied to the male threads.

No second-hand pipe shall be used, except that when a building is undergoing reconstruction or repair such gas pipe as is taken out and found in good condition may be re-run.

Sec. 7. Supports and Grades. — All pipes shall be suitably supported and stayed with pipe hooks, straps and screws.

All pipes shall be properly graded, and, if practicable, toward the meter. A bracket outlet shall preferably be run as a riser than as a drop. No gas pipe shall be laid in cement, unless the pipe and channel in which it is placed are covered with tar, nor within six (6) inches of an electric wire.

Sec. 8. Cutting and Fitting. — In the installation of the gas piping the cutting and fitting around the structural parts of the building shall be done in conformity with Sec. 25, Title IX, Secs. 5 and 12, Title XIII, and Sec. 13, Title XV.

Sec. 9. Risers. — The rising line of pipes in all buildings shall be carried up on an inside partition out of the reach of frost, and shall be placed where the stop-cock can be readily got at. In

buildings of large undivided floor spaces the risers shall be run exposed at least six (6) feet distant from any window.

Sec. 10. Drops or Outlets. — Drops or outlets less than three quarters ($\frac{3}{4}$) of an inch in diameter shall not be left more than three-quarters ($\frac{3}{4}$) of an inch below plastering, center-piece, or woodwork, and other outlets shall not project more than three-quarters ($\frac{3}{4}$) of an inch beyond plastering or woodwork.

Sec. 11. Stop-Pins. — All stop-pins to keys or cocks or fixtures shall be screwed into place.

Sec. 12. Capping and Inspection. — After the piping is run all openings shall be closed with iron caps and in no case shall lead caps be allowed, and all unused outlets shall be kept capped. All split pipe or defective fittings shall be removed and no pipe or defective fitting repaired with cement or lead will be allowed. No gas-fitters' cement shall be used except at a fixture joint. All pipes shall be examined and tested before said pipes are concealed, and due notice shall be given by the fitter to the Inspector when any pipe is ready for inspection.

Sec. 13. Tests. — The gas piping in any building shall be tested air-tight by the gas fitters under the direction of the Inspector, viz.: First, when roughing in is completed and before the floors are laid; and, second, when the entire building is completed and the work ready for gas fixtures. Said tests shall be made by having all openings closed and subjecting the piping to an air pressure test that will support a column of mercury twenty (20) inches in height at least fifteen (15) minutes, provided that in no case shall a spring or steam gauge be used.

There shall be a final test of all fixtures and pipes by two (2) inches of mercury, which must stand five (5) minutes; this test to be made in the presence of the Inspector.

On proof of a satisfactory test the Inspector shall issue a certificate of inspection to the fitter, covering said work.

Sec. 14. Gas Brackets. — All gas brackets shall be placed at least three (3) feet below any ceiling or woodwork unless the same is properly protected by a shield, in which case the distance shall not be less than eighteen (18) inches. No swinging or folding gas bracket shall be placed against any stud partition or woodwork. No gas bracket on any lath and plaster partition or woodwork shall be less than five (5) inches in length, measured

from the burner to the plaster surface or woodwork, and shall be at least two (2) inches from any door or window casing. No outlet shall be placed behind any door or within four (4) feet of any meter.

Sec. 15. Hose Outlets. — No independent connection for a hose outlet shall be placed above the stiff joint on any chandelier or pendant, but such connection shall be brought down to an accessible point.

Sec. 16. Extensions or Alterations. — Where any material extensions or alterations are to be made the work shall be done in conformity to the provisions of this Title.

No extension or alteration of any existing system of gas piping in a building in excess of fifteen (15) feet in length and unless the same is entirely exposed shall be made without reporting the same to the Inspector for inspection. Extensions shall conform in size to the table of Sec. 5, and shall be made from the largest practicable outlet.

The provisions of this section shall also apply where the use of one system is changed to another as prescribed in Sec. 2. In such cases the whole system shall be retested and certified to before a permit for such change shall be granted.

Sec. 17. Natural or Fuel Gas. — In piping any building for natural gas for fuel purposes, no one (1)-inch main shall supply more than five (5) fires, and when there are more than five (5) fires, one and one-quarter ($1\frac{1}{4}$)-inch pipe shall be used; one-half ($\frac{1}{2}$)-inch branches from mains shall not supply more than one (1) fire and three-quarter ($\frac{3}{4}$)-inch branches not more than two (2) fires, but nothing in this section shall prohibit the use of a three-eighths (3-8)-inch riser for supplying one (1) fire, if not over ten (10)-feet in length.

Sec. 18. Condemnation and Removal. — The Inspector shall promptly condemn and order the removal, reconstruction or repair of any system of gas piping or portion thereof, which does not conform to these regulations. He shall order the necessary repairs to be made when defects are found in any old system of gas piping or fixtures connected therewith, and such repairs shall be promptly made by the responsible party upon service of order or notice.

Rules and Table for Proportioning Sizes of House Pipes.*

The table on the following page is based on the well-known formula for the flow of gas through pipes. The friction, and therefore the pressure necessary to overcome the friction, increases with the quantity of gas that goes through, and as the aim of the table is to have the loss in pressure not exceed $\frac{1}{10}$ in. water pressure in 30 ft., the size of the pipe increases in going from an extremity toward the meter, as each section has an increasing number of outlets to supply. The quantity of gas the piping may be called on to pass through is stated in terms of $\frac{3}{8}$-in. outlets, instead of cubic feet, outlets being used as a unit instead of burners, because at the time of first inspection the number of burners may not be definitely determined. In designing the table, each $\frac{3}{8}$-in. outlet was assumed as requiring a supply of 10 cu. ft. per hour.

In using the table observe the following rules:

1. No house riser shall be less than $\frac{3}{4}$ in. The house riser is considered to extend from the cellar to the ceiling of the first story. Above the ceiling the pipe must be extended of the same size as the riser, until the first branch line is taken off.

2. No house pipe shall be less than $\frac{3}{8}$ in. An extension to existing piping may be made of $\frac{1}{4}$-in. pipe to supply not more than one outlet, provided said pipe is not over 6 ft. long.

3. No gas-range shall be connected with a smaller pipe than $\frac{3}{4}$ in.

4. In figuring out the size of pipe, always start at the extremities of the system and work *toward* the meter.

5. In using the table, the lengths of pipe to be used in each case are the lengths measured from one branch or point of juncture to another, disregarding elbows or turns. Such lengths will be hereafter spoken of as "sections." No change in size of pipe may be made except at branches or outlets, each "section" therefore being made of but one size of pipe.

6. If any outlet is larger than $\frac{3}{8}$ in. it must be counted as more than one, in accordance with the schedule below:

Size of outlet (inches)........	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3
Value in table	2	4	7	11	16	28	44	64

* The Denver Gas and Electric Company.

TABLE SHOWING THE CORRECT SIZES OF HOUSE PIPES FOR DIFFERENT LENGTHS OF PIPES AND NUMBER OF OUTLETS.

Number of Outlets.	Lengths of Pipes in Feet.								
	3/8-in. Pipe.	1/2-in. Pipe.	3/4-in. Pipe.	1-in. Pipe.	1¼-in. Pipe.	1½-in. Pipe.	2-in. Pipe.	2½-in. Pipe.	3-in. Pipe.
1	20	30	50	70	100	150	200	300	400
2	.....	27	50	70	100	150	200	300	400
3	.....	12	50	70	100	150	200	300	400
4	.....	.....	50	70	100	150	200	300	400
5	.....	.....	33	70	100	150	200	300	400
6	.....	.....	24	70	100	150	200	300	400
8	.....	.....	13	50	100	150	200	300	400
10	.....	.....	.....	35	100	150	200	300	400
13	.....	.....	.....	21	60	150	200	300	400
15	.....	.....	.....	16	45	120	200	300	400
20	.....	.....	.....	.....	27	65	200	300	400
25	.....	.....	.....	.....	17	42	175	300	400
30	.....	.....	.....	.....	12	30	120	300	400
35	.....	.....	.....	.....	.....	22	90	270	400
40	.....	.....	.....	.....	.....	17	70	210	400
45	.....	.....	.....	.....	.....	13	55	165	400
50	.....	.....	.....	.....	.....	.....	45	135	330
65	.....	.....	.....	.....	.....	.....	27	80	200
75	.....	.....	.....	.....	.....	.....	20	60	150
100	.....	.....	.....	.....	.....	.....	.....	33	80
125	.....	.....	.....	.....	.....	.....	.....	22	50
150	.....	.....	.....	.....	.....	.....	.....	15	35
175	.....	.....	.....	.....	.....	.....	.....	.....	28
200	.....	.....	.....	.....	.....	.....	.....	.....	21
225	.....	.....	.....	.....	.....	.....	.....	.....	17
250	.....	.....	.....	.....	.....	.....	.....	.....	14

7. If the exact number of outlets given cannot be found in the table, take the next larger number. For example, if seventeen outlets are required, work with the next larger number in the table, which is 20.

8. If, for the number of outlets given, the exact length of the "section" which feeds these outlets cannot be found in the table, the next larger length corresponding to the outlets given must be taken to determine the size of pipe required. Thus, if there are eight outlets to be fed through 55 ft. of pipe, the length next larger than 55 in the eight-outlet line in the table is 100, and as this is in the 1¼-in. column, that size pipe would

be required. Under Rule 7 the same size pipe would be required for seven outlets.

9. For any given number of outlets, do not use a smaller size pipe than the smallest size that contains a figure in the table for that number of outlets. Thus, to feed 15 outlets, no smaller size pipe than 1 in. may be used, no matter how short the "section" may be.

10. In any piping plan, in any continuous run from an extremity to the metre, there may not be used a longer length of any size pipe than found in the table for that size, as 50 ft. for $\frac{3}{4}$ in., 70 ft. for 1 in., etc. If any one "section" would exceed the limit length, it must be made of larger pipe. Thus, 6 outlets could not be fed through 75 ft. of 1-in. pipe, but $1\frac{1}{4}$ in. would have to be used. When two or more successive "sections," work out to the same size of pipe and their total length or sum exceeds the longest length in the table for that size pipe, make the "section" nearest the metre of the next larger size. For example, if we have 5 outlets to be supplied through 45 ft. of pipe, and these 5 and 5 more, making 10 in all, through 30 ft. of pipe, we should find by the table that 10 outlets through 30 ft. would require 1-in. pipe, and that 5 outlets through 45 ft. would also require 1-in. pipe, but as the sum of the two sections, 30 plus 45 equals 75 ft., is longer than the amount of 1 in. that may be used in any continuous run, the 30-ft. section, being the one nearer the metre, must be made of $1\frac{1}{4}$-in. pipe. The application of the limit in length of any one size in a continuous run may also be shown as follows: Eight outlets will allow of 13 ft. of $\frac{3}{4}$-in. pipe in the section between the eighth and ninth outlet (counting from the extremity of the system toward the metre), provided that this 13 ft. added to the total length of $\frac{3}{4}$-in. pipe that may have been used between the extremity of the run and the eighth outlet does not exceed 50 ft., which, according to the table, is the greatest length of $\frac{3}{4}$ in. allowable in any one branch of the system. Therefore, up to the eighth outlet, 37 ft. of $\frac{3}{4}$-in. pipe could have been used, and yet allow 13 ft. of $\frac{3}{4}$ in. to be used in the section between the eighth and ninth outlet. If more than 37 ft. had been used, then the entire 13 ft. between the eighth and ninth outlets would have to be of 1-in. pipe.

11. Never supply gas from a smaller size pipe to a larger one. If we have 25 outlets to be supplied through 200 ft. of pipe, and these 25 and 5 more, making 30 in all, through 100 ft. of pipe we should find by the table that 25 outlets through

200 ft. would require $2\frac{1}{2}$-in. pipe, and 30 outlets through 100 ft. would require 2-in. piping, but as under this condition a 2-in. pipe would be supplying a $2\frac{1}{2}$-in., the 100 ft. section must be made $2\frac{1}{2}$ in.

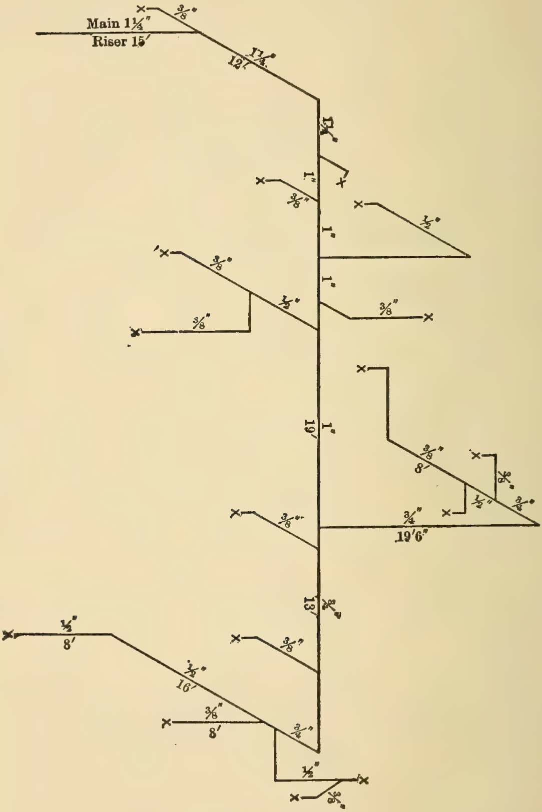


Diagram of Gas-piping.
Fig. 95

The sizes of pipes in the above diagram are in accordance with the foregoing rules and table.

Directions for Working Around Gas Piping.*

Danger of Explosion. — A gas man must never forget the danger of an explosion.

No fire must be used on any repair work, for thawing frozen ground or for any other purpose.

Smoking is especially dangerous and is forbidden on this account.

Never attempt to find a leak anywhere with a light or apply a flame to light the escaping gas.

Leaks must be located either by the sense of smell or the use of soapsuds.

Never use matches or take an unprotected flame into a building. Safety lamps can be obtained for work where other lights will be dangerous.

Gas escaping through the ground has been known to be deodorized. There is only one rule to be followed with regard to fire or lights where there is the least possibility of gas being present, and that is, most imperatively, don't.

Whenever you suspect a gas leak, immediately extinguish all open flame lights or any fire there may be in the neighborhood.

Whenever the odor of gas inside a building is reported to you, endeavor first to ascertain if the gas is escaping from the apparatus inside the building, or if the gas is leaking into the building from the soil outside or from adjoining premises. If the odor of gas is very noticeable, immediately open the windows to ventilate the premises. After making certain that no gas is being used in the premises, examine the test dial of the meter or meters to see if any gas is being passed. If no movement of the hand on a 2-foot test dial can be detected for ten minutes, with the gas pressure on the meter and no gas being used, it can be safely assumed that there is no leakage in the house piping and fixtures. If the hand on the test dial moves in this length of time with no gas being used, endeavor to locate the leak. If you can find it and it can be readily repaired, remedy the trouble. If it cannot be repaired at once, or if the leak is in apparatus which the consumer should stand the expense of repairing, soap up the leak temporarily and notify the consumer that you will have the trouble remedied, or tell him to get a plumber, as the case may be.

* Set of instructions to plumbers and gas fitters; read at a meeting of the Ohio Gaslight Association, Cincinnati, Ohio, by John M. Robb of the Peoria Gas Co., Peoria, Ill.

If gas is coming into the building from without, inspect the adjoining premises if the house is one of a block, or notify the gas office at once if you suspect the leak to be either the service or mains in the street.

Never under any circumstances leave a leak until you have remedied the trouble unless you are absolutely certain that it is of the most trivial character or have made absolutely certain the impossibility of an accident.

In the case of a broken main accompanied by the escape of a large volume of gas the convenience of some of the consumers must be sacrificed. Locate the break as closely as possible from observations at the places where the escaping gas is noticed and then bag off the section of the main in which the leak is located.

Leaks of this description are exceedingly dangerous and work must not cease until they are located and remedied.

Do not hesitate to warn smoking bystanders or loiterers where repair work in which gas is escaping or likely to escape is being carried on.

Asphyxiation. — Whenever a man has been overcome with gas it is the result of carelessness. A few simple precautions will prevent anybody from being gassed. As accidents will happen, however, these rules are given, so that in the event that such an emergency should arise you may know just what to do. Asphyxiation is the suspension of the vital functions from causes effecting the respiration or breathing. As long as the victim has not lost consciousness there is little cause for alarm.

The first thing to do is, of course, to give the victim plenty of fresh air and then call a doctor. If he is able to move, keep him walking about, as the exercise helps the respiration. Give the victim a glass of weiss beer, vichy water or any other carbonated water, or if these are unobtainable give him a pint of water in which a teaspoonful of baking soda has been dissolved. If he is very weak, give him 30 drops of aromatic spirits of ammonia and repeat the dose every 5 to 15 minutes until four doses have been given. If more than four doses be given the patient will be nauseated.

If the victim has lost consciousness, lay him on his back with a tightly rolled coat under his shoulders in order to throw his head well back. Open his clothes at the throat, chest and abdomen. Roll up the trousers from the leg. Supply heat to the extremities, either by vigorous friction or by hot bricks, hot water

bottles, plates, etc. Pull the tongue out of the mouth and hold it firmly to prevent its slipping back and falling into the throat. Make the victim breathe by kneeling at his head, grasping his arms at the elbows and pressing them vigorously to his sides; then straighten the arms, pulling them back until the hands meet over the head; then return the arms to the sides, fold them across the chest, pressing them down hard. Repeat about four or five times a minute, being careful not to make the motions too rapidly. The sole object of the motions is to fill the lungs with air and empty them, in imitation of the natural breathing.

During the entire process of artificial respiration have your assistants apply heat to the extremities, either by friction or by hot water bottles, bricks, plates, etc., and slap the chest with a wet towel.

The restoration of asphyxiated persons has been accomplished at long periods after apparent death, so be prepared to continue your artificial respiration until a doctor pronounces the victim dead.

The work to be effective is very tiresome and ten minutes at a stretch is about as long as one man can administer treatment effectively. On this account change operators before their strength is spent.

When the victim begins to breathe naturally, give him a dose of aromatic spirits of ammonia, as before directed, and cover him up warmly until you can move him.

To prevent Asphyxiation. — Never work on leaky gas mains or do work on mains or services in which gas must be allowed to escape until the trench has been made large enough to thoroughly ventilate it and afford ample working room.

Never do such work in tunnels or under the overhanging banks of trenches unless you are especially instructed to do so by the superintendent and you are working under his guidance.

When performing such work always station a man on the bank to keep the workers in sight and get them out of the ditch promptly if necessary.

Every gang on such work must be provided with life belts and a rope long enough and strong enough to pull the men out of the trench.

Never enter a house or building filled with gas without first providing the means for getting out quickly in case you are overcome. You can do this by attaching a rope to yourself when

you enter and leaving the other end in charge of assistants, who can then get you out if necessary.

These precautions may seem unnecessary to you, but you must remember them and use them should an emergency arise. Human life is precious and must not be exposed to danger heedlessly.

Soil and Vent Pipes.

The soil and vent pipes of a building are usually of cast iron, wrought iron or steel; when wrought iron or steel pipes with thread connections are used it is known as a Durham System of plumbing.

This system is used in the best work as it is more reliable and tighter than the cast iron pipes with lead joints. The wrought iron or steel pipe should not be used under ground and should always be coated to prevent rusting. Under ground cast iron pipes should always be used.

Soil and vent stacks should be run as near vertical as possible

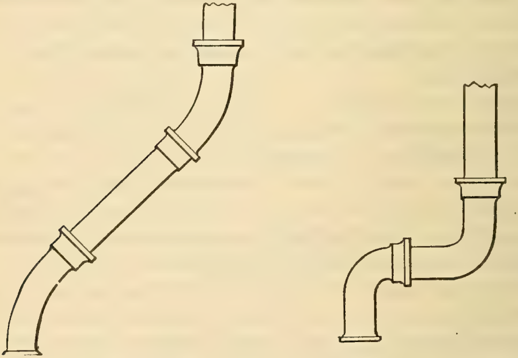


Fig. 96. Difference between offsets made with Ells and Long Bends.

and where any branches, bends or offsets are used they should be made with Y branches, long bends, etc. Fig. 96 shows the difference between an offset made with a $\frac{1}{4}$ elbow and one made with $\frac{1}{8}$ bends.

Where short bends or angles are made there should be a cleanout at this point as shown at 6, page 345.

At various points in a soil system there should be provided

flushing connections so that the entire system can be flushed out at any time.

Pages 344 to 357 show the various soil pipe fittings as manufactured and their names, and when laying out a soil system the plumber should select the fittings that will give the easiest bends and angles.

Sizes of Soil Pipes. — The soil pipe from any closet fixture should not be less than 4 inches; the plumbing ordinances of the larger cities specify that the least diameter of any soil pipe permitted is 4 inches; this of course is the soil pipe to closets and does not include waste pipes from sinks and lavatories.

Sizes of Waste Pipes. — Suitable size wastes for the various fixtures are as follows:

Waste from bath, $1\frac{1}{2}$ to 2 inches in diameter.
Branch, closet to soil pipe riser, 4 inches in diameter.
Waste from urinal, $1\frac{1}{2}$ inches.
Waste from basin fixture, $1\frac{1}{4}$ or $1\frac{1}{2}$ inches in diameter.
Waste from single wash tub, $1\frac{1}{2}$ inches in diameter.
Waste from two or three wash tubs, $1\frac{1}{2}$-inch branch, and 2-inch trap.
Waste from pantry sink, $1\frac{1}{2}$ inches in diameter.
Waste from kitchen sink, 2 inches in diameter.
Waste from slop sink, 2 to 3 inches in diameter.
Waste from shower bath, $1\frac{1}{2}$ inches in diameter.

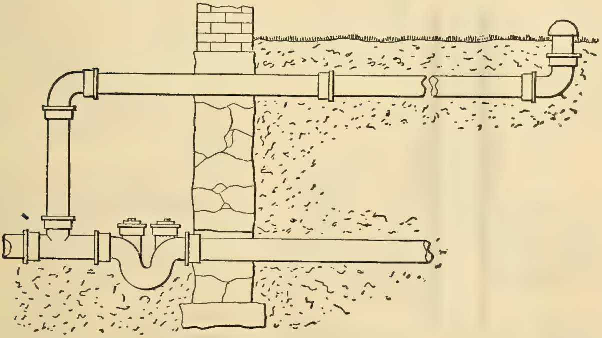


Fig. 97. Fresh Air Inlet.

Fresh Air Inlet. — Every soil or drainage system to a building should have a fresh air inlet, which should be located

immediately back of the main trap. When the trap is located inside the building the fresh air inlet should be run as shown by Fig. 97.

Vent Pipes. — The vent pipe from the soil system should extend up through the roof in such a position or high enough to get a good draught. Just before passing through the roof it should be increased to give it a larger area and prevent it from becoming closed with frost.

Size of Vents. — The size of vent pipe will depend on the number of stories of the building and the number of fixtures vented. The main vent for traps of water closets or for traps of other fixtures, in buildings of four stories and under, should be at least 2 inches in diameter.

In buildings from four to six stories the vent should be not less than $2\frac{1}{2}$ inches in diameter.

Vent pipes for soil or waste stacks up to four inches in diameter should not be less than 2 inches, and for larger soil or waste stacks, should be of a diameter equal to half the diameter of the soil or waste pipe to be vented.

The following table gives the sizes on vent pipes as usually used:

For traps 3 inches or larger, use a 2-inch vent.
For traps 2 inches in diameter, use a $1\frac{1}{2}$-inch vent.
For traps $1\frac{1}{2}$ inches in diameter, use a $1\frac{1}{2}$-inch vent.

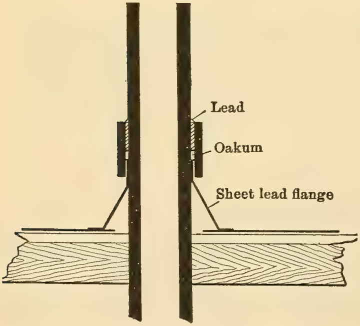


Fig. 98. Vent Pipe Roof Connection.

The rise or stack of vent or soil pipe should always be started from a foot rest fitting such as No. 12 on page 345, so as to carry the weight of the stack.

Vent pipes should be so arranged that there will be no run of horizontal vent pipe over 12 feet.

Roof Flange for Vent Pipes. — Fig. 98 shows how the roof flange on a vent pipe can be made perfectly water-tight. There are several special makes of roof plates on the market but they require special fittings. The

method shown by Fig. 98 is to turn a lead flange up around the vent pipe as shown and then slip a large size coupling over the

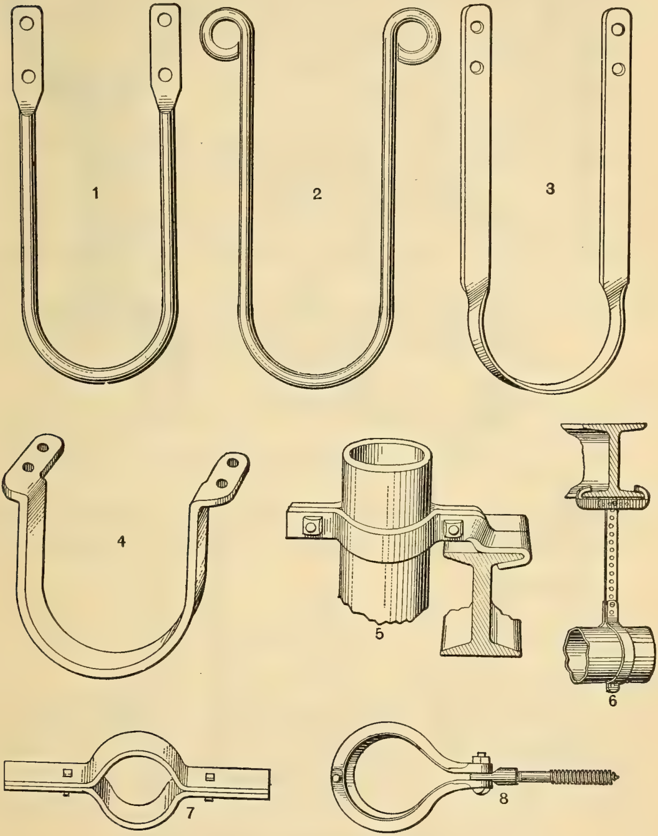


Fig. 99. Various Pipe Hangers.

pipe so as to lap down over the lead flange, then calk the coupling with oakum and run full of lead; then calk the lead and the job is completed and water-tight.

SUPPORTING SOIL AND VENT PIPES.

The vent and soil pipes should be securely anchored or hung with wrought iron hangers so that the entire line of pipe will be held firmly. Fig. 99 shows several different styles of hangers.

No. 1 is a common U-hanger.
No. 2 is a U-hanger with loops.
No. 3 is a strap U-hanger.
No. 4 is a soil pipe bracket.
No. 5 is a combination pipe and I-beam clamp for risers.
No. 6 is a hinge ring extension bar and beam clamp.
No. 7 is a clamp for use in chases.
No. 8 is a hanger with lag screw for wooden beams.

When the soil or vent pipes are supported by hangers there

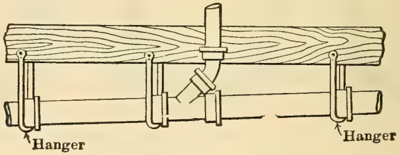


Fig. 100. Wrought Iron Hangers.

should be a hanger to each length of pipe as shown by Fig. 100. When the pipe runs near the floor it should be supported on

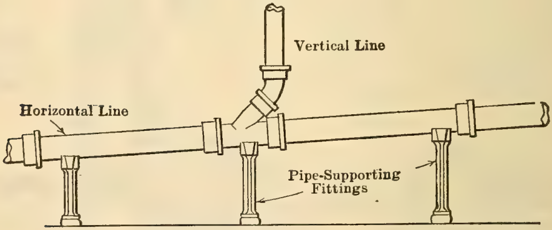


Fig. 101. Soil Pipe on Supporting Legs.

brick or pipe supporting piers as shown by Fig. 101, one to each length of pipe.

Fig. 102 shows a pipe rest for soil pipe, the height of it being regulated by the length of the pipe leg of the rest.

When the soil or vent pipe is run up a brick chase the pipe should be supported with pipe clamps such as shown by Fig. 103, the clamp being placed under the hub or coupling of the pipe, and the ends built into the brick work.

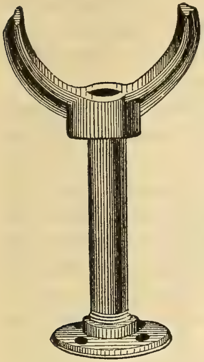


Fig. 102. Pipe Rests for Soil Pipes.

SUPPORTING WASTE PIPES. — Waste pipes leading from wash stands, etc., should always be supported where they pass through the floors so as not to strain the trap by having the weight of the pipes hanging on it.

If the pipe is lead a flange should be soldered or wiped on it at the floor as shown by Fig. 104.

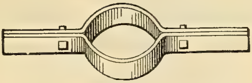


Fig. 103. Wrought Iron Pipe Clamp.

Waste pipe flanges with slip joints are now made for brass pipes as shown by Fig. 105. This flange rests on the floor and carries the weight of the pipe.

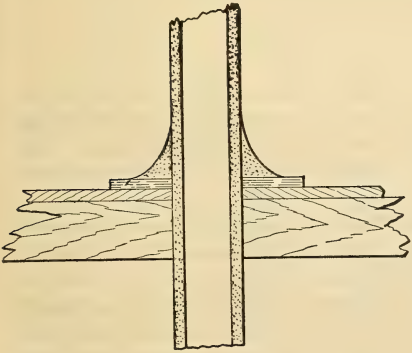


Fig. 104. Lead Riser supported at Floor.

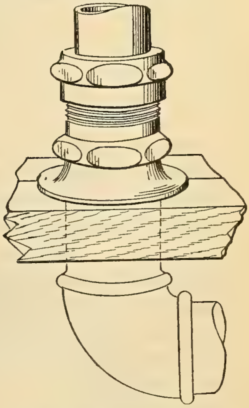


Fig. 105. Supporting Flange for Waste Pipes.

TESTING SOIL AND VENT PIPES. — After the vent, soil and drain pipes of a building are in place the entire system should be sub-

jected to a hydrostatic or water test before any of the fixtures are put in place, and before any pipe or drain is covered up. The main outlet should be plugged outside the building and all outlets to fixtures, etc., in the building plugged; then the entire system should be filled with water to the roof level, or top of the vent pipe. This is the only absolutely sure test.

In case of a tall building, one or two floors can be tested separately; the pipes being filled with water to a height to give the desired pressure for test.

Pipes which show tight under a smoke or peppermint test will often develop leaks when put under the water test. When the pipes are filled with water let it stand several hours and then go over the entire system and examine every joint and piece of pipe. This is the only way to make certain all joints are tight.

The pressure obtained with the water at various heights is as follows:

5	feet	of	water	will	give	a	pressure	of	2	pounds	per	square inch.
10	"	"	"	"	"	"	"	"	4	"	"	"
15	"	"	"	"	"	"	"	"	6	"	"	"
20	"	"	"	"	"	"	"	"	8	"	"	"
25	"	"	"	"	"	"	"	"	10	"	"	"
30	"	"	"	"	"	"	"	"	13	"	"	"
35	"	"	"	"	"	"	"	"	15	"	"	"
40	"	"	"	"	"	"	"	"	17	"	"	"
45	"	"	"	"	"	"	"	"	19	"	"	"
50	"	"	"	"	"	"	"	"	21	"	"	"

Smoke or Peppermint Test. — After the fixtures are all in place and connected up, the smoke or peppermint test should be given to test if all traps are sealed and connections tight. The smoke machine, of which Figs. 106 and 107 are types, should be connected with the pipe system at as low a point as possible, and if convenient in a room that can be closed up to prevent the smell of the smoke or peppermint from permeating through the building. After the entire system is pumped full of smoke or air carrying the odor of the peppermint, and a pressure of about 5 pounds or more per square foot is raised, all the fixtures and connections should be examined by some person who has just come in from the fresh air, and who will be able to locate the smell of smoke at any point.

When it is desired to make the water test after the fixtures are connected up, the connections have to be broken and sealed up.

If it is a union connection it can be sealed by removing the gasket and inserting in its place a lead washer the size of the

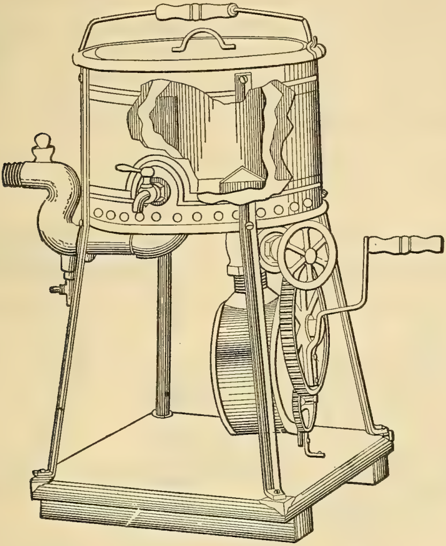


Fig. 106. Smoke Testing Machine.

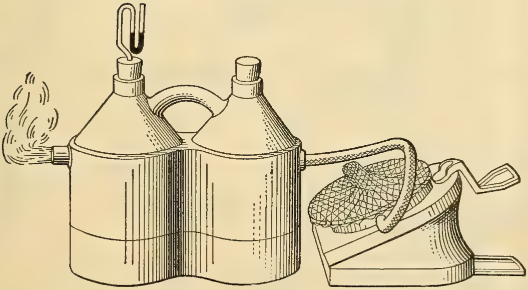


Fig. 107. Smoke and Peppermint Testing Machine.

large diameter of the gasket, and screwing the union tight; if it is a lead pipe with putty joint the pipe must be closed and soldered.

Closets have to be lifted off and a sheet of lead soldered over

the opening. Provisions should always be made for testing when the piping is put in place, and the test made before the fixtures are set. The connection to the street sewer should not be made until after the test so the pipe can be plugged at this point outside the building. If there is a cleanout plug near this point a plug can be inserted and the pipe stopped.

It is a good idea to have the lead ends and brass ferrules for closets, etc., put in the pipe before the water test is made, as the test then will show up any sand holes in the brass ferrules if there should be any.

Names, Sizes, etc., of Soil Pipe Fittings.

For weight of fittings, see page 199. Figs. 108 to 116 show the various fittings for soil and vent pipes. Their names are as follows:

1. Quarter bend.
2. Quarter bend, with heel inlet.
3. Quarter bend, with side inlet.
4. Quarter bend, with double hub.
5. Increasing quarter bend.
6. Increasing quarter bend, with cleanout.
7. Long quarter bend.
8. Long quarter bend, with foot rest.
9. Long quarter bend, with hand hole and foot rest.
10. Double hub eighth bend.
11. Milwaukee or Reilly Bend.
12. Double hub elbow, with foot rest.
13. Fifth bend.
14. Milwaukee or Reilly Bend, with foot rest.
15. Short sanitary elbow.
16. Double quarter bend.
17. Sixth bend.
18. Eighth bend.
19. Increasing eighth bend.
20. Increasing eighth bend, with cleanout.
21. Long eighth bend.
22. Sixteenth bend.
23. Double hub sixteenth bend.
24. Tee branch.
25. Tee branch, with side outlet.
26. Tee branch, with trap screw on side.
27. Long tee branch.
28. Tee branch, tapped for iron pipe.

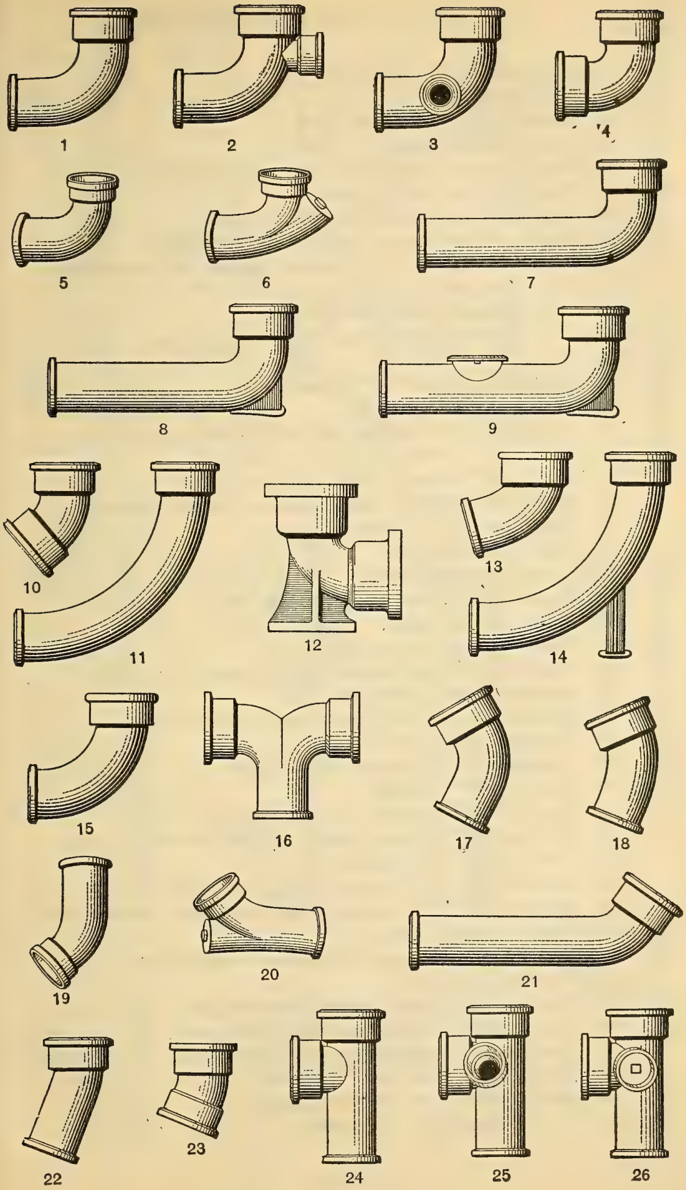


Fig. 108. Soil Pipe Fittings.

29. Tee branch, all hub ends.
30. Sanitary tee.
31. Sanitary tee, with side inlet.
32. Long sanitary tee.
33. Sanitary tee, with brass trap screw on side.
34. Sanitary tee, all hub ends.
35. Special reducing sanitary tee branch.
36. Sanitary tee branch, tapped for iron pipe.
37. Inverted sanitary tee branch, tapped for iron pipe.
38. "Y" branch.
39. "Y" branch, with side inlet.
40. "Y" branch, with brass trap screw on side.
41. Long "Y" branch.
42. Special reducing "Y" branch.
43. Inverted "Y" branch.
44. Inverted "Y" branch, tapped for iron pipe.
45. Half "Y" branch.
46. Half "Y" branch, with side inlet.
47. Half "Y" branch, with brass trap screw on side.
48. Long half "Y" branch.
49. Cross or double tee.
50. Cross, with side inlet.
51. Cross, with brass trap screw on side.
52. Cross, all hub ends.
53. Cross, tapped for iron pipe.
54. Sanitary cross or double sanitary tee.
55. Sanitary cross, with side inlet.
56. Sanitary cross, with brass trap screw on side.
57. Sanitary cross, all hub ends.
58. Sanitary cross, tapped for iron pipe.
59. Double "Y" branch.
60. Double "Y" branch, with side inlet.
61. Double "Y" branch, with brass trap screw on side.
62. Double half "Y" branch.
63. Double half "Y" branch, with side inlet.
64. Double half "Y" branch, with brass trap screw on side.
65. Double angle branch.
66. Monitor branch (made with four branches only).
67. Ventilating branch.
68. Ventilating branch, tapped for iron pipe.
69. Tee cleanout, round hand hole and cover.
70. Tee cleanout, square hand hole and cover.
71. Square tee "Sure Seal" cleanout.
72. Sanitary tee "Sure Seal" cleanout.
73. "Y" "Sure Seal" cleanout.

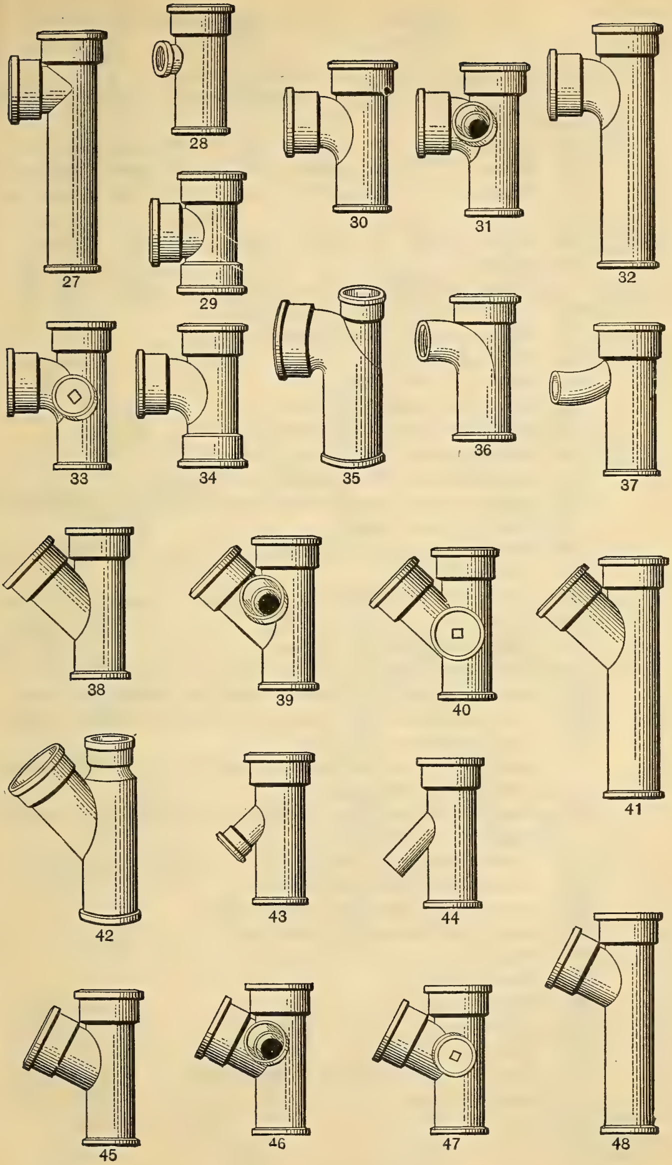


Fig. 109. Soil Pipe Fittings.

74. Combination "Y" and eighth bend.
75. Upright "Y" branch or combination "Y" and eighth bend.
76. Boston "TY" or sanitary tee branch, long pattern.
77. Boston "TY" or sanitary tee branch, short pattern.
78. Boston "TY" or sanitary tee branch, with 2-inch top vent.
79. Boston long "TY," with 2-inch top vent.
80. Offset.
81. Offset, with 2-inch vent.
82. Offset, with 2-inch heel inlet.
83. Offset, with 2-inch side inlet.
84. Milwaukee sanitary offset.
85. Increaser, for calking.
86. Increaser, tapped for iron pipe.
87. Short increaser, tapped for iron pipe.
88. Increaser and offset, for calking.
89. Increaser and offset, tapped for iron pipe.
90. Increaser and ventilating branch, with straight side outlet for calking.
91. Increaser and vent branch, with bent side outlet for calking.
92. Increaser, with straight side outlet, tapped for iron pipe.
93. Long increaser, for calking.
94. Long increaser, tapped for iron pipe.
95. Long increaser, for calking, with hub branch on side.
96. Long increaser, for calking, with side branch tapped for iron pipe.
97. Long increaser, for calking, with two side branches tapped for iron pipe.
98. Long increaser, for calking, with bent side branch tapped for iron pipe.
99. Ventilating cap, spigot end.
100. Ventilating cap, hub end.
101. Long ventilating cap, spigot end.
102. Long ventilating cap, hub end.
103. Single hub.
104. Double hub.
105. Straight sleeve.
106. Reducer.
107. Thimble.
108. Thimble, with hand hole and cover.
109. Extension piece.

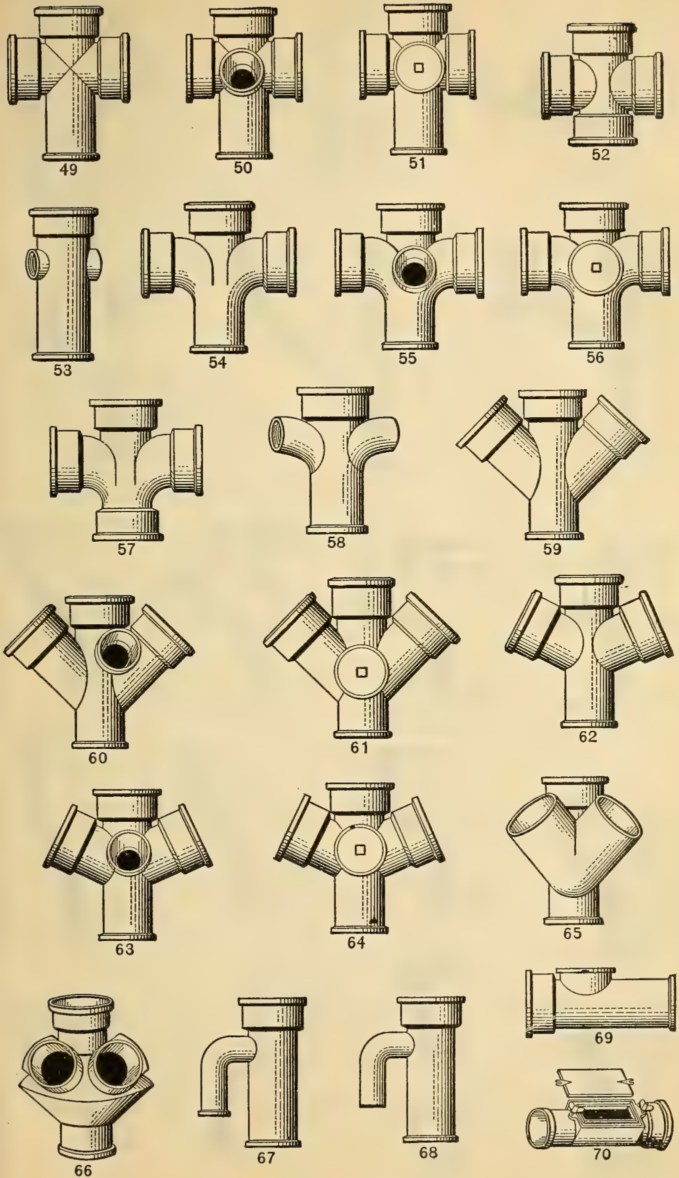


Fig. 110. Soil Pipe Fittings.

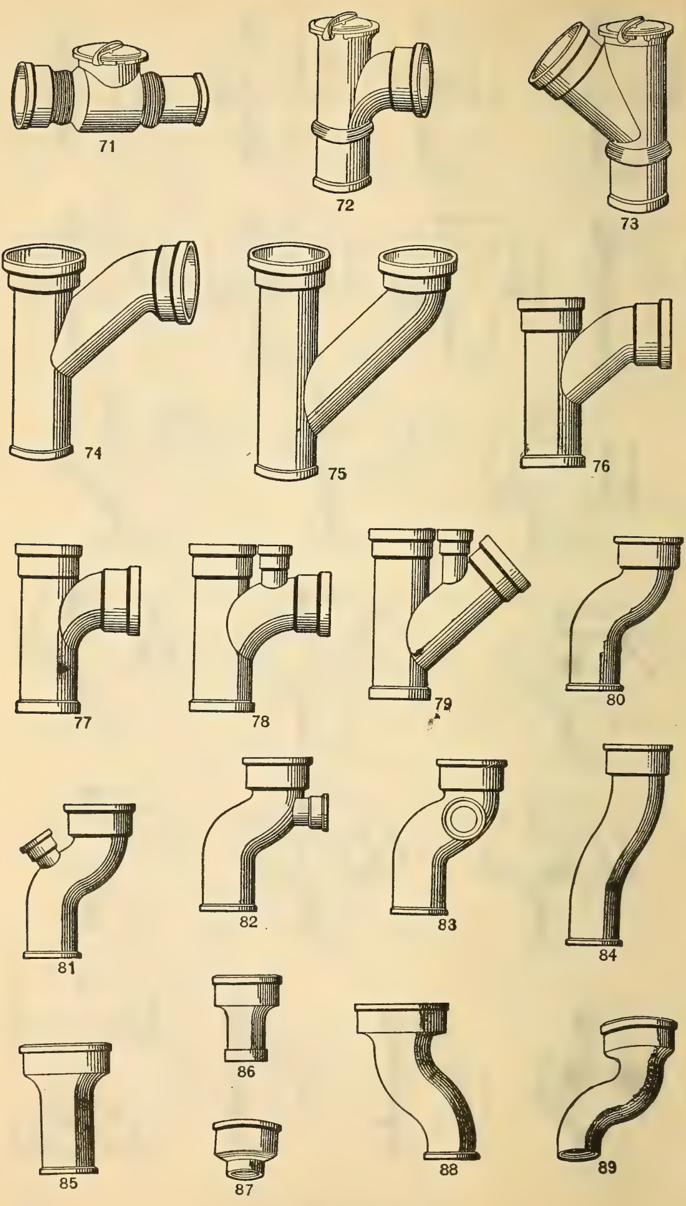


Fig. 111. Soil Pipe Fittings.

Green House Fittings.

110. Return bend, single hub.
111. Return bend, double hub.
112. Return bend, spigot back outlet.
113. Return bend, hub back outlet.
114. "H" branch, hub ends.
115. Double elbow.
116. Triple elbow.
117. Quadruple elbow.
118. Three-way branch.

Special Fittings.

119. Reducer.
120. Increaser.
121. Graduated closet fitting.
122. }
123. } Flanged closet fittings.
124. }
125. }

Traps.

126. Full "S" trap.
127. Three-quarter "S" trap.
128. Half "S" or "P" trap.
129. Running trap.
130. Full "S," with hand hole and cover.
131. Three-quarter "S," with hand hole and cover.
132. Half "S" or "P," with hand hole and cover.
133. Running trap, with hand hole and cover.
134. Full "S," with top vent.
135. Three-quarter "S," with top vent.
136. Half "S" or "P," with top vent and brass trap screw on side.
137. Running trap, with hub for vent.
138. Running trap, with hubs for double vent.
139. Baltimore regulation running trap, with hubs for double vents.
140. Full "S" trap, with top vent and brass trap screw on side.
141. Three-quarter "S" trap, with top vent and brass trap screw on side.
142. Half "S" of "P" trap, with top vent and brass trap screw on side.
143. Full "S," with hand hole and cover and 2-inch heel inlet.

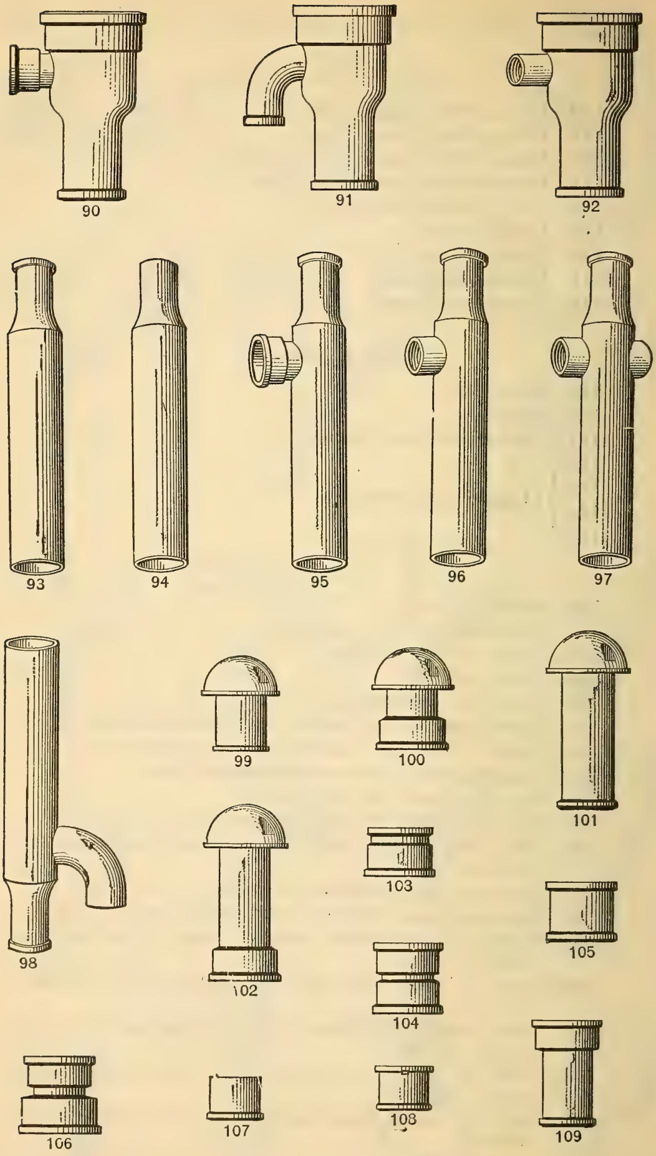


Fig. 112. Soil Pipe Fittings.

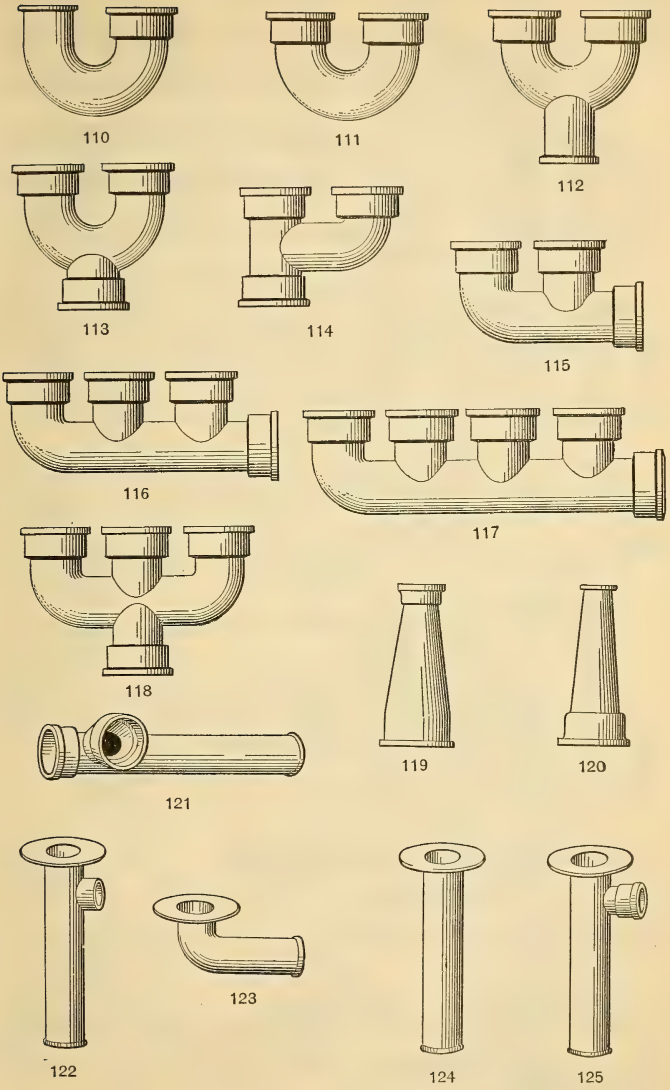


Fig. 113. Soil Pipe Fittings.

144. Three-quarter "S" trap, with hand hole and cover and 2-inch heel inlet.
145. Half "S" or "P" trap, with hand hole and cover and 2-inch heel inlet.
146. Full "S" trap, with hand hole and cover and 2-inch side inlet.
147. Three-quarter "S" trap, with hand hole and cover and 2-inch side inlet.
148. Half "S" or "P" trap, with hand hole and cover and 2-inch side inlet.
149. Running trap with "Y" branch and vent.
150. "Sure Seal" trap, full "S."
151. "Sure Seal" trap, three-quarter "S."
152. "Sure Seal" trap, half "S" or "P."
153. "Sure seal" trap, running.
154. Deep "Sure Seal" trap, full "S."
155. Deep "Sure Seal" trap, three-quarter "S."
156. Deep "Sure Seal" trap, half "S" or "P."
157. Deep "Sure Seal" trap, running.
158. Deep "Sure Seal" trap, combination.

Special Cast Iron Drainage Fittings, Screw Threads.

159. Long turn elbow.
160. Long turn forty-five degree elbow.
161. Sixty-degree elbow.
162. Forty-five degree bend.
163. Forty-five degree reducing "Y."
164. Twenty-two and one-half degree bend.
165. Eleven and one-fourth degree bend.
166. Forty-five degree "Y."
167. Forty-five degree double "Y."
168. Sixty-degree "Y."
169. "Y" branch, "T" pattern.
170. Five and five-eighths degree bend.
171. Three-way elbow.
172. Cross.
173. Elbow with cleanout.
174. Closet tee.
175. Closet tee.
176. Base elbow, with cleanout.
177. Base elbow, with cleanout, cast iron pipe to wrought iron pipe.
178. Elbow with shoe.
179. Basin tee.

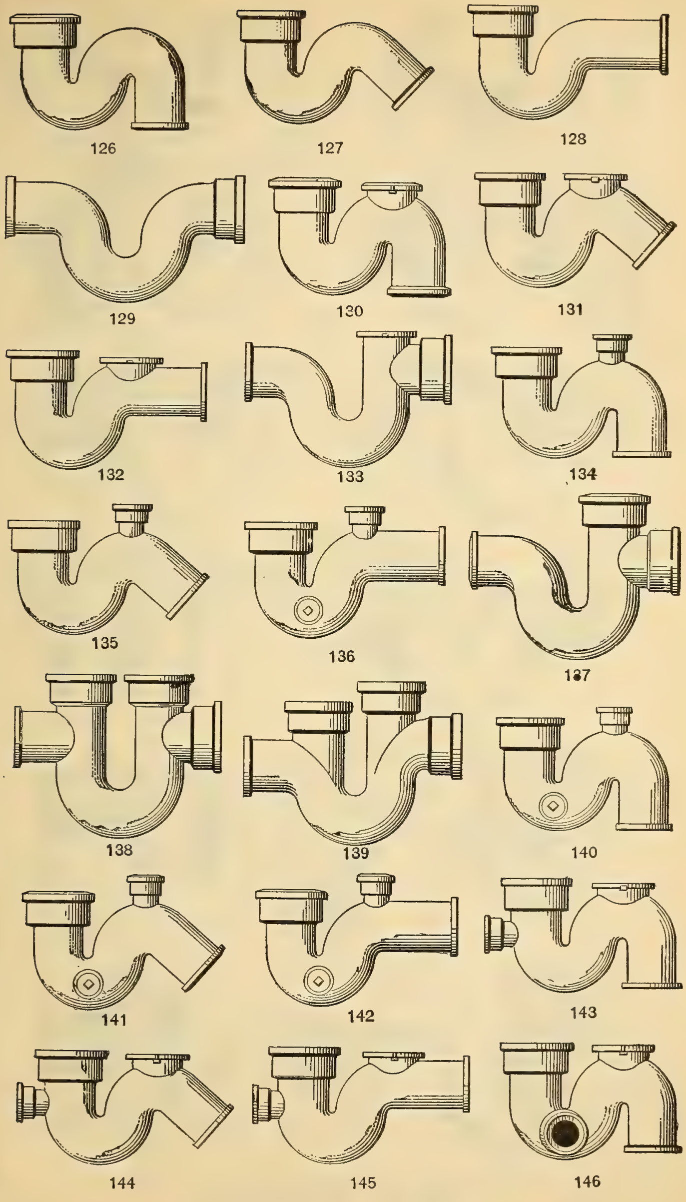
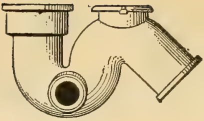


Fig. 114. Soil Pipe Fittings.



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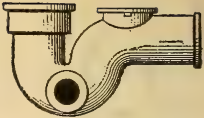

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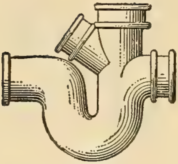

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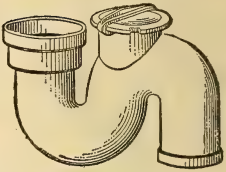

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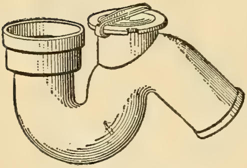

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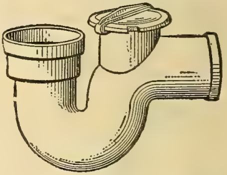

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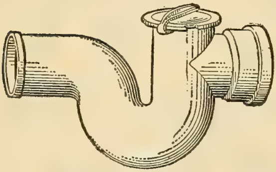

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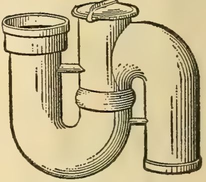

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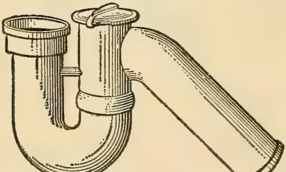

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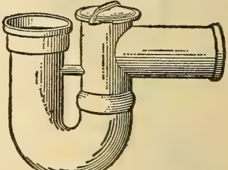

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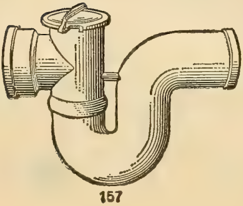

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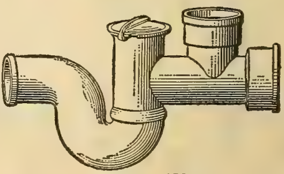

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Fig. 115. Soil Pipe Fittings.

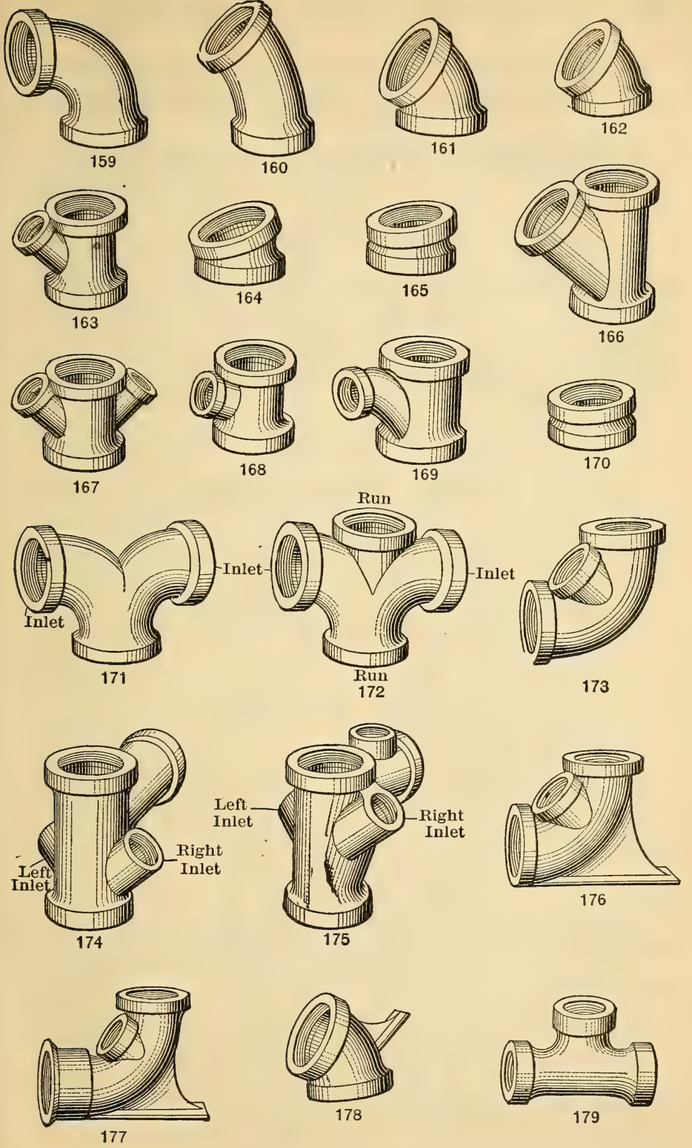


Fig. 116. Soil Pipe Fittings for "Durham System."

LIST OF STANDARD SIZES OF CAST-IRON FITTINGS.

ADOPTED AT MEETING OF MAKERS OF CAST-IRON FITTINGS JUNE 24, 1897.

Sizes differing from standard sizes, if furnished, are to be charged at 5 per cent gross discount higher than standard sizes.

STRAIGHT SIZES.

Elbows and Tees—$\frac{1}{4}$ to 12 inch.	Y Branches—$\frac{1}{2}$ to 10 inch.	Offsets—$\frac{3}{4}$ to 6 to offset 4 inch, 6 inch, and 8 inch.
Elbows: 45° — $\frac{3}{8}$ to 12 inch.	Elbows: right and left—$\frac{1}{4}$ to 3 inch.	Plugs—$\frac{1}{4}$ to 12 inch.
Return Bends—$\frac{3}{4}$ to 3 inch.	Crosses—$\frac{1}{2}$ to 12 inch.	Flange Unions—$\frac{1}{2}$ to 12 inch.
Caps and Locknuts—2 to 12 inch.		

ELBOWS — REDUCING SIZES.

$\frac{1}{2}\times\frac{3}{8}$	$1\frac{1}{4}\times\frac{3}{4}$	$2\times1\frac{1}{2}$	$3\times2\frac{1}{2}$	$4\times2\frac{1}{2}$	8×6
$\frac{3}{4}\times\frac{1}{2}$	$1\frac{1}{4}\times\frac{1}{2}$	$2\times1\frac{1}{4}$	3×2	$4\frac{1}{2}\times4$	...
$1\times\frac{3}{4}$	$1\frac{1}{2}\times1\frac{1}{4}$	2×1	$3\frac{1}{2}\times3$	5×4	...
$1\times\frac{1}{2}$	$1\frac{1}{2}\times1$	$2\frac{1}{2}\times2$	$4\times3\frac{1}{2}$	6×5	...
$1\frac{1}{4}\times1$	$1\frac{1}{2}\times\frac{3}{4}$	$2\frac{1}{2}\times1\frac{1}{2}$	4×3	6×4	...

REDUCING COUPLINGS.

$2\frac{1}{2}\times2$	$3\frac{1}{2}\times3$	$4\times2\frac{1}{2}$	5×4	6×5	8×6
$2\frac{1}{2}\times1\frac{1}{2}$	$3\frac{1}{2}\times2\frac{1}{2}$	4×2	5×3	6×4	10×8
$3\times2\frac{1}{2}$	$4\times3\frac{1}{2}$	$4\frac{1}{2}\times4$	...	6×3	12×10
3×2	4×3	...	...	7×6	...

TEES — BULL HEAD.

Tees with both ends of run the same size, with the outlet larger, thus:

are known as Bull Head, and are read, 1×2.

$\frac{3}{8}\times\frac{1}{2}$	$\frac{3}{4}\times1\frac{1}{4}$	$1\frac{1}{4}\times2$	$2\times2\frac{1}{2}$	$3\frac{1}{2}\times4$	6×7
$\frac{1}{2}\times1$	$\frac{3}{4}\times1$	$1\frac{1}{4}\times1\frac{1}{2}$	$2\frac{1}{2}\times4$	4×6	...
$\frac{1}{2}\times\frac{3}{4}$	1×2	$1\frac{1}{2}\times2\frac{1}{2}$	$2\frac{1}{2}\times3$	4×5	...
$\frac{3}{4}\times2$	$1\times1\frac{1}{2}$	$1\frac{1}{2}\times2$	3×4	5×6	...
$\frac{3}{4}\times1\frac{1}{2}$	$1\times1\frac{1}{4}$	2×3	$3\times3\frac{1}{2}$	6×8	...

LIST OF CAST-IRON FITTINGS — *Continued.*

TEES — REDUCING ON RUN.

Tees reducing on run, thus:

```
    1¼
    |
2———┴———1½
```

are read, 2×1½×1¼.

½×⅜×½	1½×¾×1½	3×2½×2	4×2×4
½×⅜×⅜	1½×¾×1¼	3×2½×1½	4×2×3
¾×½×1	1½×¾×1	3×2½×1¼	4×2×2½
¾×½×¾	1½×¾×¾	3×2½×1	4×2×2
¾×½×½	1½×½×1½	3×2×3	4×2×1½
¾×⅜×¾	1½×½×1¼	3×2×2½	4×1½×4
¾×⅜×⅜	2×1½×2½	3×2×2	4×1¼×4
1×¾×2	2×1½×2	3×2×1½	4×1×4
1×¾×1½	2×1½×1½	3×2×1¼	5×4×5
1×¾×1¼	2×1½×1¼	3×2×1	5×4×5
1×¾×1	2×1½×1	3×1½×3	5×4×4
1×¾×¾	2×1½×¾	3×1½×2½	5×4×3
1×¾×½	2×1½×½	3×1½×2	5×4×2½
1×½×1	2×1¼×2	3×1¼×3	5×4×2
1×½×¾	2×1¼×1½	3×1×3	5×3×5
1×½×½	2×1¼×1¼	3½×3×3	5×3×4
1×⅜×1	2×1¼×1	3½×3×2½	5×3×3
1¼×1×2	2×1¼×¾	3½×3×2	5×3×2½
1¼×1×1½	2×1×2	3½×3×1½	5×3×2
1¼×1×1¼	2×1×1½	3½×2½×3	5×2½×5
1¼×1×1	2×1×1¼	3½×2½×2½	5×2½×4
1¼×1×¾	2×1×1	3½×2½×2	5×2½×3
1¼×1×½	2×1×¾	3½×2×3½	5×2×5
1¼×¾×2	2×¾×2	3½×1½×3½	6×5×6
1¼×¾×1½	2×¾×1½	3½×1¼×3½	6×5×5
1¼×¾×1¼	2×½×2	3½×1×3½	6×4×6
1¼×¾×1	2½×2×3	4×3½×3½	6×3×6
1¼×¾×¾	2½×2×2½	4×3½×3	6×2½×6
1¼×½×1½	2½×2×2	4×3½×2½	7×6×7
1¼×½×1¼	2½×2×1½	4×3×4	7×6×6
1½×1¼×2	2½×2×1¼	4×3×3½	7×6×5
1½×1×2	2½×2×1	4×3×3	7×5×5
1½×¾×2	2½×1½×2½	4×3×2½	8×7×6
1½×1¼×1½	2½×1½×2	4×3×2	8×6×8
1½×1¼×1¼	2½×1½×1½	4×3×1½	8×6×7
1½×1¼×1	2½×1½×1¼	4×3×1¼	8×6×6
1½×1¼×¾	2½×1½×1	4×3×1	8×5×8
1½×1¼×½	2½×1¼×2½	4×3×¾	8×5×5
1½×1×1½	2½×1¼×2	4×2½×	8×4×8
1½×1×1¼	2½×1×2½	4×2½×3	10×8×8
1½×1×1	2½×¾×2½	4×2½×2½	12×8×10
1½×1×¾	3×2½×3	4×2½×2	12×8×8
1½×1×½	3×2½×2½	4×2½×1½	....

LIST OF CAST-IRON FITTINGS — *Continued.*

TEES — REDUCING ON OUTLET.

Tees which reduce on the outlet, thus:

```
    1¼
     |
2————————2
```

are read, 2×1¼.

½× ⅜	2 ×1½	3 ×1¼	4 ×1½	5 ×2	8× 5
¾× ½	2 ×1¼	3 ×1	4 ×1¼	5 ×1½	8× 4
¾× ⅜	2 ×1	3 × ¾	4 ×1	5 ×1¼	8×3½
1 × ¾	2 × ¾	3½×3	4 × ¾	6 ×5	8× 3
1 × ½	2 × ½	3½×2½	4½×4	6 ×4	8×2½
1 × ⅜	2½×2	3½×2	4½×3½	6 ×3½	8× 2
1¼×1	2½×1½	3½×1½	4½×3	6 ×3	10× 8
1¼× ¾	2½×1¼	3½×1¼	4½×2½	6 ×2½	10× 6
1¼× ½	2½×1	3½×1	4½×2	6 ×2	10× 5
1½×1¼	2½× ¾	4 ×3½	5 ×4	7 ×6	10× 4
1½×1	3 ×2½	4 ×3	5 ×3½	7 ×5	12×10
1½× ¾	3 ×2	4 ×2½	5 ×3	7 ×4	12× 8
1½× ½	3 ×1½	4 ×2	5 ×2½	8 ×6	12× 6

CROSSES — REDUCING SIZES.

The outlets of a cross are always the same size, and are indicated by the last figure. Thus: A cross

```
      ½
      |
¾ ————————— ¾
      |
      ½
```

is called a ¾×½ cross.

A cross reducing on the run, thus:

```
       1
       |
1½ ————————— 1¼
       |
       1
```

is called a 1½×1¼×1 cross.

½× ⅜	1¼× ¾	2 ×1¼	2½× ¾	3½×3	5 ×4	6 ×3	10× 8
½× ¼	1¼× ½	2 ×1	3 ×2½	3½×2½	5 ×3	6 ×2½	10× 7
¾× ⅜	1½×1¼	2 × ¾	3 ×2	3½×2	5 ×2½	6 ×2	12×10
¾× ½	1½×1	2½×2	3 ×1½	4 ×3½	5 ×2	7 ×6	12× 8
1 × ¾	1½× ¾	2½×1½	3 ×1¼	4 ×3	6 ×5	7 ×5	. . .
1 × ½	1½× ½	2½×1¼	3 ×1	4 ×2½	6 ×4	8 ×7	. . .
1¼×1	2 ×1½	2½×1	3 × ¾	4 ×2	6 ×3½	8 ×6	. . .

LIST OF CAST-IRON FITTINGS—*Continued.*

BUSHINGS.

NOTE. — Bushings reducing one size only, up to and including $2\frac{1}{2}$ inches, are malleable, and will be found, therefore, listed among the malleable fittings.

$\frac{1}{2}\times\frac{1}{4}$	$1\frac{1}{2}\times\frac{3}{4}$	$3\times2\frac{1}{2}$	$3\frac{1}{2}\times1$	$4\frac{1}{2}\times3$	6×4	7×3	9×6
$\frac{3}{4}\times\frac{3}{8}$	$1\frac{1}{2}\times\frac{1}{2}$	3×2	$4\times3\frac{1}{2}$	$4\frac{1}{2}\times2\frac{1}{2}$	$6\times3\frac{1}{2}$	$7\times2\frac{1}{2}$	10×8
$\frac{3}{4}\times\frac{1}{4}$	$2\times1\frac{1}{4}$	$3\times1\frac{1}{2}$	4×3	$5\times4\frac{1}{2}$	6×3	7×2	10×6
$1\times\frac{1}{2}$	2×1	$3\times1\frac{1}{4}$	$4\times2\frac{1}{2}$	5×4	$6\times2\frac{1}{2}$	8×7	12×10
$1\times\frac{3}{8}$	$2\times\frac{3}{4}$	3×1	4×2	$5\times3\frac{1}{2}$	6×2	8×6	12×8
$1\times\frac{1}{4}$	$2\times\frac{1}{2}$	$3\frac{1}{2}\times3$	$4\times1\frac{1}{2}$	5×3	7×6	8×5	12×6
$1\frac{1}{4}\times\frac{3}{4}$	$2\frac{1}{2}\times1\frac{1}{2}$	$3\frac{1}{2}\times2\frac{1}{2}$	$4\times1\frac{1}{4}$	$5\times2\frac{1}{2}$	7×5	8×4	...
$1\frac{1}{4}\times\frac{1}{2}$	$2\frac{1}{2}\times1\frac{1}{4}$	$3\frac{1}{2}\times2$	4×1	5×2	$7\times4\frac{1}{2}$	8×3	...
$1\frac{1}{4}\times\frac{3}{8}$	$2\frac{1}{2}\times1$	$3\frac{1}{2}\times1\frac{1}{2}$	$4\frac{1}{2}\times4$	6×5	7×4	9×8	...
$1\frac{1}{2}\times1$	$2\frac{1}{2}\times\frac{3}{4}$	$3\frac{1}{2}\times1\frac{1}{4}$	$4\frac{1}{2}\times3\frac{1}{2}$	$6\times4\frac{1}{2}$	$7\times3\frac{1}{2}$	9×7	...

Various Methods, Hints and Short Cuts.

PLUMBERS' PORTABLE WORK BENCH. — Fig. 117 shows how to construct a portable work bench, which is very useful for plumbers, steam fitters, etc. The frame and legs are made as

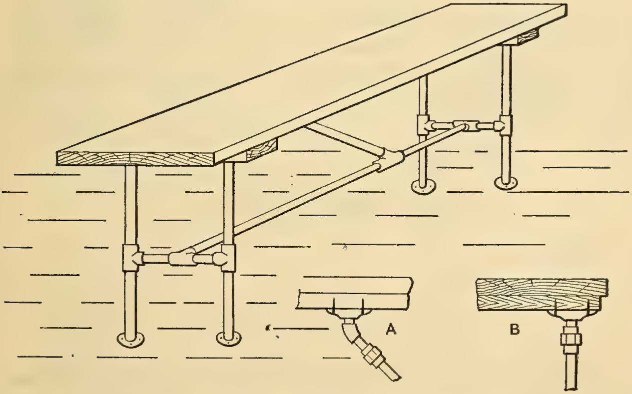


Fig. 117. Plumbers' Portable Work Bench.

shown of pipe, the four legs and brace being fastened to the top with floor flanges as shown at *A* and *B*. A short nipple is

screwed in the flange and the legs and brace connected to the nipple with a union connection as shown. When not in use or to be transported, the unions are opened and the frame will then turn so it will lay flat, the legs turning down on a plane with the longitudinal brace of the frame. To set up the bench the legs are turned at right angles to the longitudinal brace, placed in position under the top and the unions screwed together.

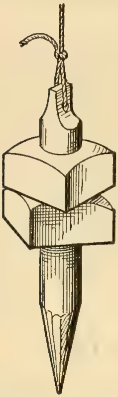


Fig. 118. Improvised Plumb Bob.

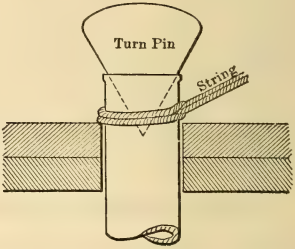


Fig. 119. Holding Lead Waste to Flange it.

An Improvised Plumb Bob. — A handy plumb bob can be made by cutting out a stick and screwing onto it a couple of nuts as shown by Fig. 118. This can be made in a few moments and makes a very good bob.

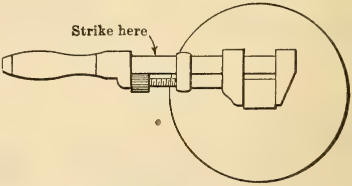


Fig. 120. Starting Cleanout Plugs.

To Hold Waste Pipe while Turning Flange.* — When flanging the end of a lead waste pipe which extends up through the floor, take a strong string or piece of twine and put it around the pipe in the form of a slip knot as shown by Fig. 119; now by

* From "The Metal Worker," by permission.

means of this string the pipe can be held up while the flange is being turned with the turn pin.

To Remove Brass Cleanout Plugs. — Brass cleanout plugs which are hard to start may be started by giving a steady pull on the monkey wrench and then striking it a few sharp blows with a hammer as shown by Fig. 120.

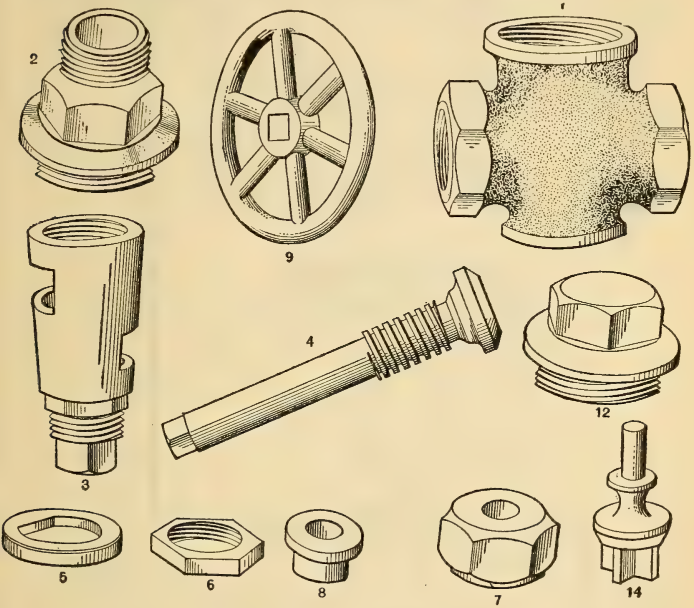


Fig. 121. Names of Parts of Valves.

Globe Valves.
1 Case
2 Bonnet
3 Plug
4 Stem
5 Washer for plug
6 Nut for plug
7 Packing nut
8 Packing gland
9 Hand Wheel

Check Valves.
1 Case
12 Bonnet
3 Plug
14 Valve
5 Washer for plug
6 Nut for plug

WATER TANK INDICATOR OR GAUGE. — Fig. 122 shows how to construct an indicator for reading the depth of water in a tank. The indicator is made by attaching a gear wheel to the

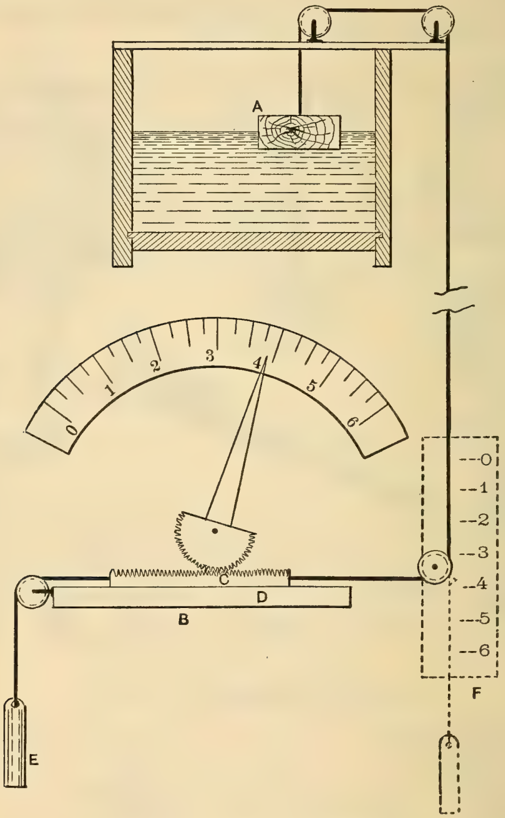


Fig. 122. Water Tank Gauge.

arm of the indicator as shown, the gear of the wheel engaging with the rack gear of the slide *C*. One end of this slide is connected by a chain to the float in the tank and the other end is connected to a weight as shown at *E*. When the tank is empty

the float will draw the slide along and move the indicator hand to 0, and as the tank fills with water the float is raised and the weight draws the slide along, thus moving the hand along the dial, showing the exact depth of water in the tank. Or an indicator can be arranged as shown at *F* with the pointer fastened on the chain as shown.

To Start Stoppage in a Drain Pipe.* — When a drain pipe becomes stopped up and cleaning out the trap does not remedy

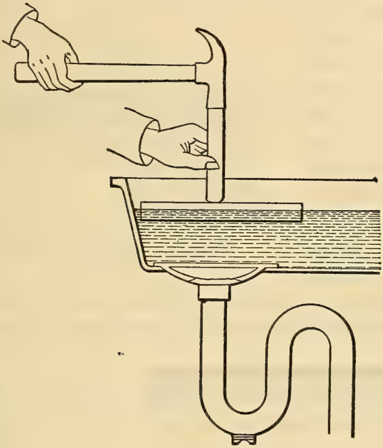


Fig. 123. Starting Stoppage in Waste.

the trouble, fill the sink or basin partly full of water and lay a wooden block about eight inches square on the water over the outlet. Take a piece of stick and holding it as shown by Fig. 123, strike several sharp blows with a hammer. The shock of the blows forces the water into the pipe and has a tendency to start any stoppage.

Vise Used as Drill Press.* — An ordinary vise can be used as a drill press, as shown by Fig. 124. A small hole is drilled in the face of one of the jaws of the vise into which the head of the drill ratchet is inserted, the drill then being turned in the usual way.

Drills for Brick or Stone. — For drilling in brick or stone have the drill made with double cutters as shown by Fig. 125;

* From "Popular Mechanics."

it will cut much faster and make a straighter hole than a drill with one cutting edge.

To Locate an Obstruction in a Flue.* — Fig. 126 shows how an obstruction in a flue may be located with the assistance of a mirror. The mirror is held in the flue at an angle to show a reflection of the flue, looking up.

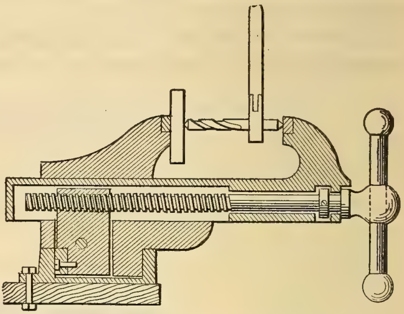


Fig. 124. Vice used as a Drill Press.

To Split a Belt. — Take a short piece of board or plank, and on it tack two strips of wood of the thickness of the belt, and of the width of the belt apart. On top of these strips nail another short piece of board, thus making an opening between the two boards just large enough for the belt to pass through, as shown by Fig.

Fig. 125. Drill with Double Cutter Face.

127. Now drive a knife blade in the lower plank in such a position as to cut the belt to the desired width, shove the belt through and take hold of the two ends of the belt *A* and *B* and pull the belt through, thus splitting it in two pieces on the knife as shown.

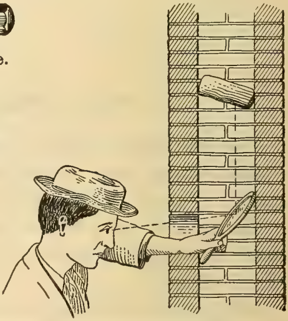


Fig. 126. Locating an Obstruction in a Flue.

To Sling a Pipe. — Fig. 128 shows how to hitch to a pipe to be hoisted on end. A hitch of this kind will not slip.

To Find the Circumference of a Circle with the Two-Foot Rule. — Measure up from the center hinge of the rule

* From "The Metal Worker."

$3\frac{13}{16}$ inches as shown in Fig. 129. Spread the blades of the rule until the distance between these two points equals the diameter of the circle. Then the distance between the two ends of the rule will equal the circumference.

In Fig. 129 the diameter is shown as $1\frac{1}{4}$ inches and the circumference then is $3\frac{15}{16}$ inches.

To find the diameter when the circumference is known, make the distance between the two ends of the rule equal the circumference. Then the distance between the two points $3\frac{13}{16}$ inches from the center of the hinge will equal the diameter.

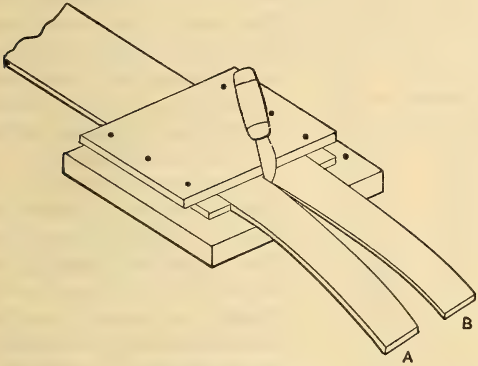


Fig. 127. Splitting a Belt.

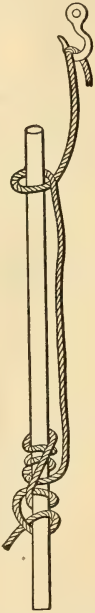


Fig. 128. Hitch to Hoist Pipe.

To Crimp a Stove Pipe. — To crimp a stove pipe without a crimper, slip the pipe over the end of a studding, and with a dull chisel or hatchet crimp it as shown by Fig. 130.

Connecting a Hot Water Heater or Water back to Boiler. — The correct method of connecting a hot water heater or water back to the boiler, to insure circulation is very simple, yet proves a "puzzle" to a good many plumbers. Fig. 131 shows how the connections should be made, *A* being the boiler and *B* the heater.

To Connect a Hot Water Heater to Boiler in Conjunction with a Water Front. — Fig. 132 shows how a hot water heater can be connected to a boiler and used in conjunction with

a water front in a range, or the gas heater used independently. The supply from the heater being connected to the hot water supply from the boiler allows hot water to be drawn direct from the heater without it passing into the boiler. Connected in this manner allows either the water front or heater to be used to heat the water in the boiler and by placing a valve at *A* the circulation of the boiler can be cut off and water drawn direct from the heater when used in warm weather.

CONNECTING A HOT WATER BOILER TO TWO SOURCES OF HEAT. — Fig. 133 shows how the connections should be made to a hot water boiler when it is desired to use two sources of heat, as a coil in the furnace in winter and a water front in the kitchen range, or a gas heater in summer. As shown, either source of heat can be used independently. In case both sources of heat are to be used at the same time, the return from the boiler should be run direct to the coil in the furnace and the flow from the coil run through the water front or heater to the boiler.

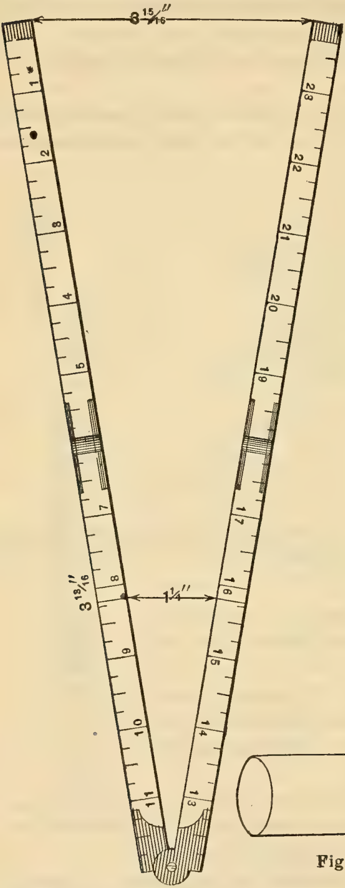


Fig. 129. To find Circumference of Circle with a Rule.

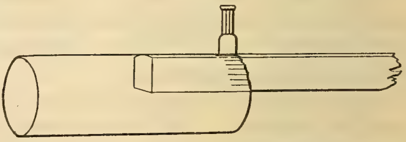


Fig. 130. Crimping Stove Pipe.

To fasten a Hose to a Pipe. — To fasten a hose to a piece of pipe where there is to be some pressure and danger of the hose slipping off, as is often the case when blowing out boiler tubes with steam, take a short piece of pipe as *A* (Fig. 134), and swedge the end of it out bell shape as shown; now work the hose over the bell part of the pipe and put on a clamp as at *B*. The more strain on the pipe now, the tighter it gets. The pipe can now be connected up with a union wherever desired.

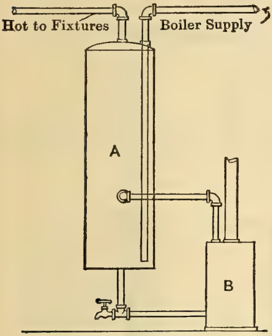


Fig. 131. Heater to Boiler Connection.

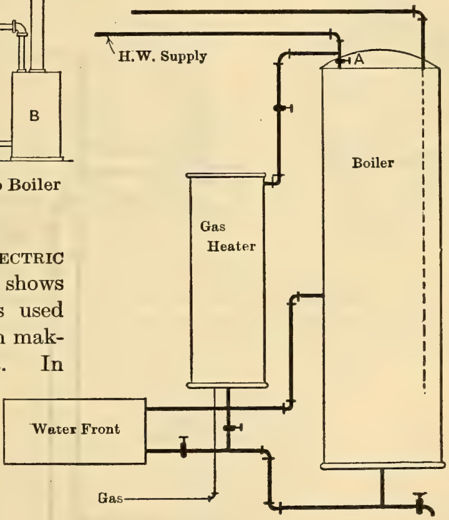


Fig. 132. Connecting Hot Water Heater and Water Front to same Boiler.

Bases of Electric Lamps. — Fig. 135 shows the different bases used by manufacturers in making electric lamps. In ordering lamps it is always necessary to specify the socket of the fixtures so the lamps will fit: as "Edison," "T–H," etc.

Inserting Gaskets. — When inserting a gasket between two flanges that cannot be separated to any great distance there is often trouble to get the gasket into position between the flanges. To overcome this trouble take a piece of stiff paper and fold as shown by Fig. 136 with the gasket between the paper; now the paper and gasket can be slipped in between the flanges with

little trouble, and after one or two bolts are put in place the paper can be taken out.

Cutting Gaskets. — When cutting rubber gaskets keep the cutter or knife blade wet with water and it will cut much easier.

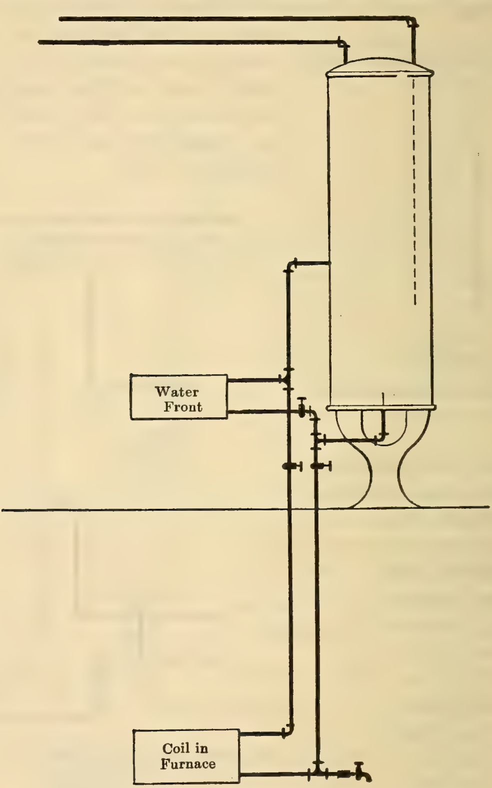


Fig. 133. Connecting Boiler to Two Sources of Heat.

To remove an Old Gasket. — To remove a gasket when the flanges of the pipes can be separated but very little is usually a difficult problem unless a length of pipe is taken out. A simple way to remove the gasket is to drive a cold chisel in the lower side of the joint sufficient to loosen the flanges and then take an

old saw and run in through the joint, sawing out the gasket; after sawing partly through, drive the cold chisel in the top of

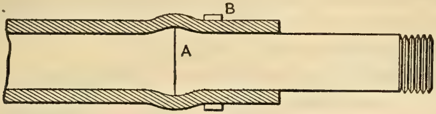
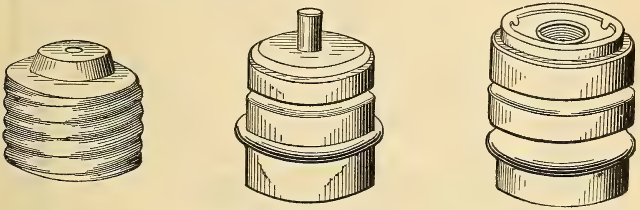


Fig. 134. Pipe Swedged to prevent Hose blowing off.

the joint to keep the flanges from pinching the saw and saw out the balance of the gasket.



STANDARD EDISON SCREW BASE. WESTINGHOUSE BASE. THOMSON-HOUSTON BASE.

Fig. 135. Bases of Electric Lamps.

PIPE-BENDING FORMER. — Fig. 137 shows a former for bending pipe to a radius. The body of the former should be made

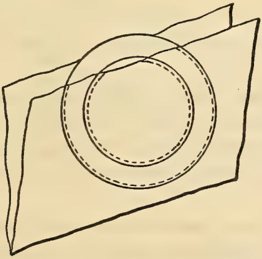


Fig. 136. Method of inserting a Gasket.

out of 2-inch plank with the desired radius cut on one end as shown. This edge of the plank is then grooved so the pipe to be bent will lay in the groove. Two strap bands are put on to hold

the pipe in position on top of the plank. The straight piece of pipe is placed in position under the small wheel in the lever and through the strap bands; then the lever is pulled forward to bend the pipe as shown. This device is very handy for making the bends in electric wire conduits.

BENDING PIPE. — Pipe up to $\frac{3}{4}$ inch can be bent to form turns, offsets, etc. A tool called the "Hicky" is often used for bending the pipe. It is made with a tee large enough to pass over

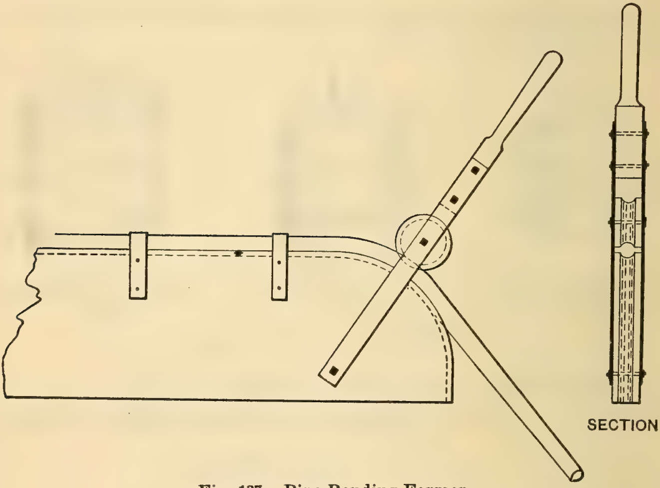


Fig. 137. Pipe Bending Former.

the pipe to be bent and a piece of pipe screwed in the side outlet of the tee for a handle or lever. The tool is used as shown in Fig. 138 and is very handy for bending pipe, conduits, etc. For some bends or offsets it is necessary to use two "Hickys" as shown.

For bending large pipe use the pipe as a lever if there is any place convenient to obtain a purchase on the pipe. If there is no such place handy, rig up a frame of studding as shown by Fig. 139; with this arrangement it is possible to bend pipe up to two inches.

TO MELT UP OLD LEAD PIPE, ETC.* — Fig. 140 shows an

* From "Popular Mechanics."

arrangement of a piece of cast iron soil pipe and a blow-pipe furnace. The pipe is hung as shown with the flame entering the lower end. The lead pipe to be melted is shoved in at the top

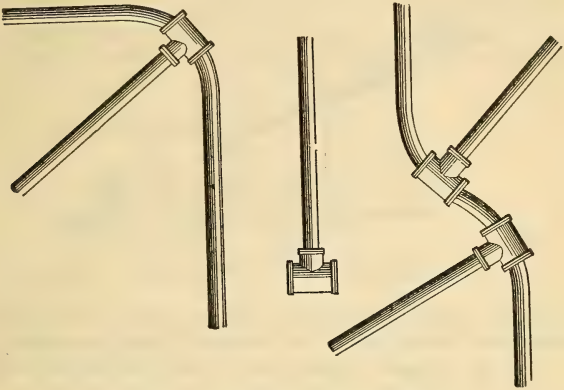


Fig. 138. Bending Pipe with a "Hicky."

end of the pipe. Lead melts very rapidly in this contrivance and pure lead is the result, as the dross and dirt is burned up.

STREET SERVICE CONNECTIONS. — Water companies, generally,

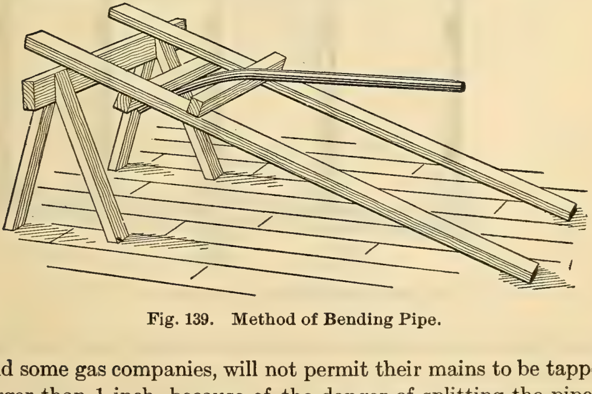


Fig. 139. Method of Bending Pipe.

and some gas companies, will not permit their mains to be tapped larger than 1 inch, because of the danger of splitting the pipe if weakened with a larger tapping, yet it is often necessary to provide a service of greater capacity than 1 inch, and when this

is necessary several 1-inch tappings are made and connected at the outlet end for larger service. It is expensive as well as inconvenient to insert a tee in the main, as this would necessitate

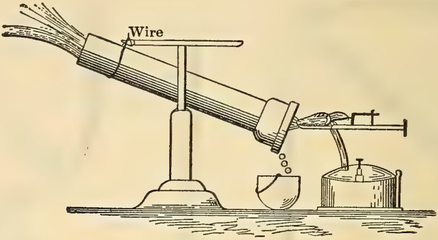


Fig. 140. Lead Melting Device.

cutting the main and shutting off the water; hence service branches are usually put in as described above and shown by Fig. 141, the several connections to give the desired supply

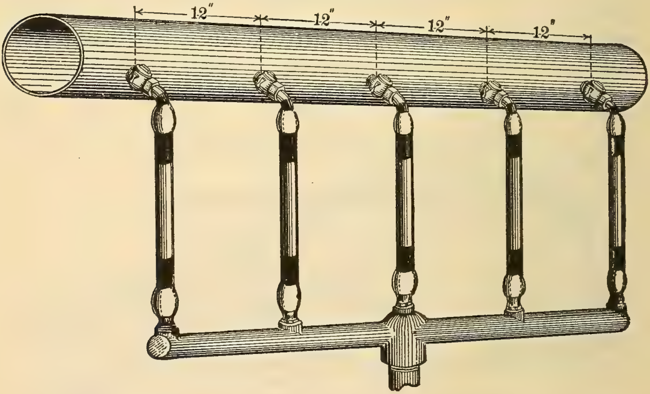


Fig. 141. Street Service Connection.

being connected to a large cross pipe as shown, which is in turn connected to the service main.

Fig. 142 shows a water connection manufactured by James B. Clow & Sons. The inlet connections are all made for use with lead or iron pipe to the main, and have union joints. The

outlet connection is also made with union joint and for lead or iron pipe.

Wherever used they give excellent satisfaction, and are a great improvement over the old method of making large connections, and are much cheaper.

MEASURING PIPE AND FITTINGS. — When taking the lengths

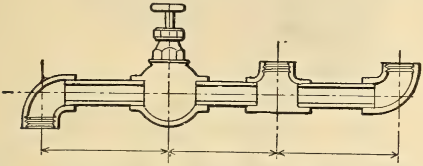


Fig. 142. Correct Method of taking Pipe Measurements.

of runs of pipe always take the measurement to the center of the fittings, as shown by Fig. 143.

TO PUT ON A VALVE OR STOP-COCK WITHOUT SHUTTING OFF THE WATER. — It often happens that it is desired to put a valve

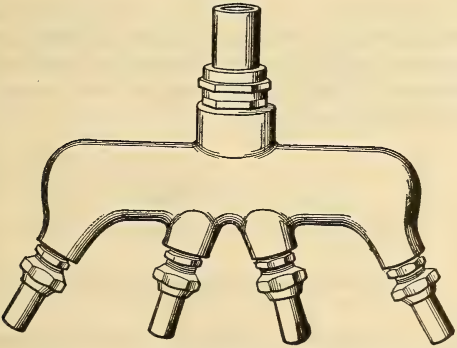


Fig. 143. Clows' Street Service Connection.

or stop-cock in a pipe where it is inconvenient to shut off the water or gas. Fig. 144 shows how this can be done. Take a short piece of pipe and screw on the cock or valve; then cut the main or pipe near a coupling; remove the coupling, leaving the threaded end of the pipe clear; now take the piece of pipe with

the valve on and holding it in the position shown screw it on the pipe. Have the cock or valve open so the water can pass through it; after it is screwed firmly on the pipe the valve or cock can be closed.

SEWER CLEANER. — Fig. 145 shows a sewer rod or cleaner used by the Post Plumber at Fort D. A. Russell, Wyo. It has

Fig. 144. Screwing on Stop-Cock without shutting off Water.

been used effectively up to 150 feet. As shown, the handle or rod is made in sections of any desired length, the hook joint being of such construction that it cannot come apart when in the pipe.

Fig. 146 shows a spring steel sewer rod; this is very flexible and will turn curves and elbows.

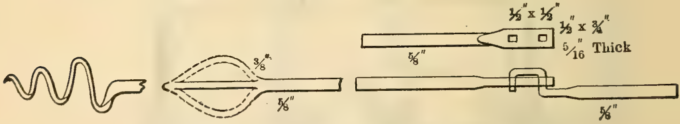


Fig. 145. Device for cleaning Sewers.

TO BUILD A CESSPOOL. — Fig. 147 shows the general construction of a cesspool, which will give good satisfaction. The inlet is intended to empty into the small chamber as shown where all solid matter will be deposited and the liquids will be drawn off into the large chamber. If desired to have an outlet of overflow it can be put in the large chamber as shown. If the cesspool is built in porous soil or gravel the cement bottom can be omitted and the liquid allowed to percolate through the soil

or gravel. The walls of the cesspool can be built either of brick or concrete.

SEPTIC CESSPOOL. — The ordinarily constructed cesspool of

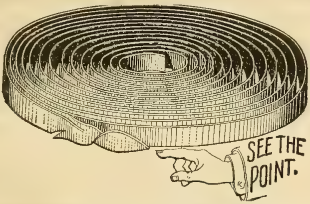


Fig. 146. Flexible Steel Sewer Rod.

one chamber as is largely used is satisfactory so long as the soil or gravel in which it is built does not become clogged with the grease and solids of the sewage. This may occur in a very short

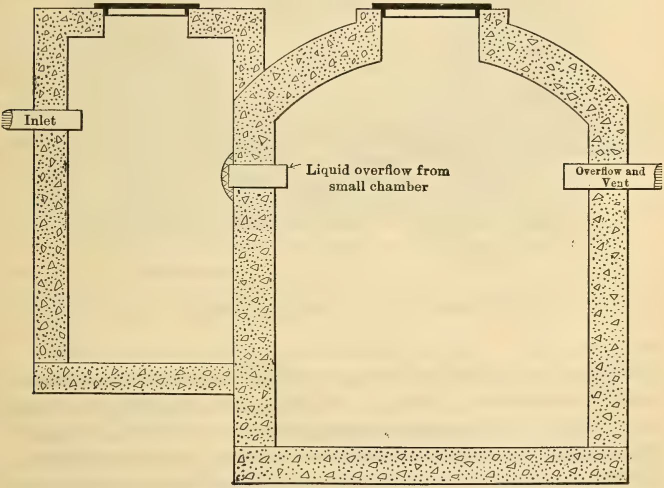


Fig. 147. Construction of Cesspool.

time in case the soil or gravel is not very porous. The bottom soon becomes choked with sediment and grease, and the water line rises, thus bringing fresh surfaces around the sides in use.

These gradually close with the floating grease, etc., forcing the water line still higher and higher until the pool is full and nearly water-tight.

To overcome this objection Fred K. Betts, Assistant Engineer of the Department of Water Supply of New York, has designed a cesspool as shown by Fig. 148.

The design shows a septic tank and leaching pool in the one construction. The aim of the design is to arrest the sediment

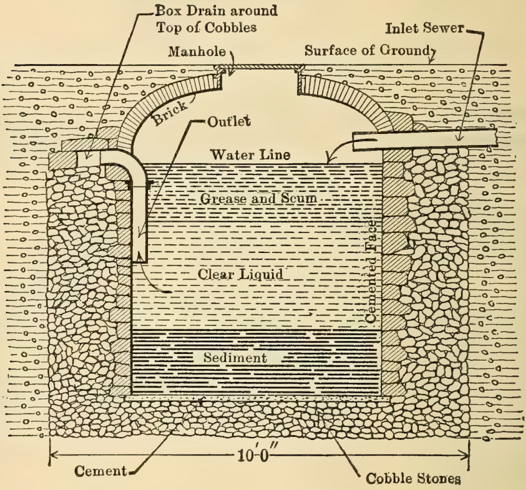


Fig. 148. Septic Cesspool, designed by Fred. K. Betts.

and scum and bring only comparatively clear liquid in contact with the absorbing surfaces, thereby prolonging the life and usefulness of the cesspool. By proportioning the tight inner chamber so as to have a capacity for about 36 hours' output, septic action may, it is stated, take place without purification and the attending odor and gases.

As shown by Fig. 148, the solid matter settles to the bottom of the pool and the grease and light matter floats on top of the sewage, while the liquid in the center, comparatively free from grease or solids, is drawn off through the outlet as indicated.

Water Bag for Stopping Gas Pipe. * — At a recent meeting in Cincinnati of the Ohio Gas Light Association a scheme for stopping up a pipe by means of a bag was forwarded by H. B. Benner, Guelph, Ontario. The idea is represented by Fig. 149. The bag is made of cloth such as is usually used for bed sheeting, cut as follows: The cloth is given a circumference about $1\frac{1}{2}$ in. larger than the circumference of the pipe, sewed inside and outside and dipped in linseed oil to make it hold water. The bag is placed over the hook shown in detail at *A* and put into the pipe by means of this hook. The hook is then removed and a $\frac{3}{4}$-in. pipe fastened to the mouth of the bag. Water is poured into the bag and filling the bag stops the flow of gas.

The pipe is supported by the stake. To remove the bag the hand is placed at the mouth of the bag and pulled gradually out of the pipe. On pulling slowly, which act will force the bag to the top surface of the pipe, the water is caused to rush out in a few seconds. From 2 to 3 lbs. pressure can be created in the bag, depending on the height of the water column, and but 15 seconds are necessary to insert the bag and cut off the flow of gas. This, of course, is a detail of particular interest to operation men of gas supply companies. It is stated that a 10-in. bag will suffice for a 10 to 8-in. pipe, a 6-in. bag for 6 and 4-in. pipes, and a 4-in. bag for 4, 3 and 2-in. pipes.

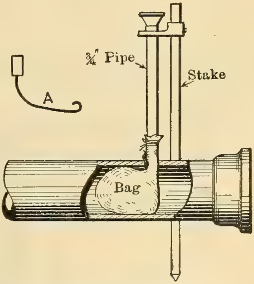


Fig. 149. Water Bag for stopping Gas Pipe.

Supporting Heavy Pipe on Long Spans. — To support a run of pipe over a span where it is not desired to use a bridge truss, use a hog chain as shown by Fig. 150. This has very often been used in street work with good success.

Equation of Pipes by the Steel Square. — To find the diameter of a pipe to carry the capacity of two smaller ones: — Take the diameter of the two smaller pipes on the tongue and blade of the square and measure the diagonal from these two points, which will give the diameter of the large pipe of equal capacity of the two smaller ones. *Example.* To find the size

* "The Metal Worker."

pipe to carry the capacity of a 3-inch and a 4-inch pipe:—Take 4 inches on the blade of the square and 3 inches on the tongue. Measure the diagonal, which is found to be 5 inches and which is the diameter of the pipe required.

The same rule can be used by drawing lines as follows:

Suppose it is desired to find the size of pipe necessary to carry the contents of a $1\frac{1}{2}$-inch, a 2-inch and a $2\frac{1}{2}$-inch pipe.

Draw two lines at right angles to each other, as 1–2 and 2–3,

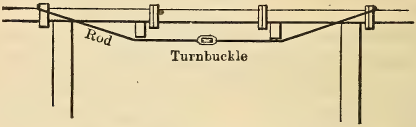


Fig. 150. Pipe supported on Hog Chain.

Fig. 151, the one line being $1\frac{1}{2}$ inches in length and the other line 2 inches long; these lines represent the diameters of the two smaller pipes.

Now draw the diagonal 1–3, which gives the diameter of a pipe equal in capacity to the two smaller ones; now draw 3–4 at right angles to 1–3 and $2\frac{1}{2}$ inches in length to represent the $2\frac{1}{2}$-inch pipe; now draw the diagonal 1–4, which gives the desired diameter of a pipe equal in capacity to the three smaller ones.

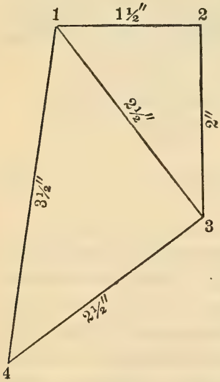


Fig. 151. Equation of Pipes.

This method can be continued to find the combined capacity of any number of pipes.

Syphon on Steam Gauges. — A syphon of some kind must be used on every steam gauge to prevent anything but water entering the gauge spring. Fig. 152 shows the syphon generally used.

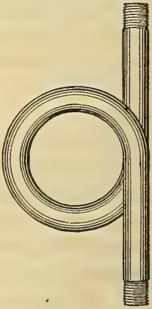


Fig. 152. Steam Gauge Syphon.

Closet Connection to Soil Pipe. — The old common method of connecting a water closet to the soil pipe was to turn the lead

connection back over the floor and set the closet in a bed of putty. This made a very poor joint; while it might not show a leak, still a joint of this kind was seldom gas-tight. The next improvement was the rubber gasket, which was much better than putty

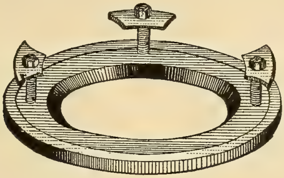


Fig. 153. Closet Floor Plate.

but not satisfactory on account of the rubber soon decaying, or becoming hard and brittle. Both these methods have been done away with in some of the larger cities, their plumbing laws prohibiting the use of putty, plaster, cement, rubber or leather

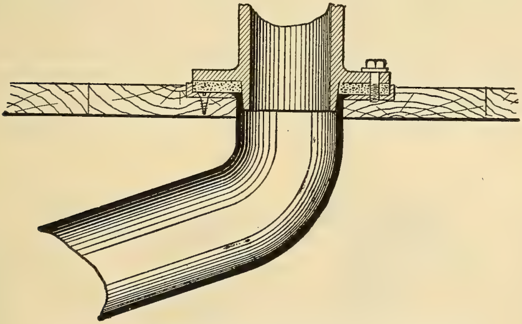


Fig. 154. Ordinary Floor Plate and Gasket in place.

gaskets. Floor plates such as shown by Fig. 153 are usually used, the lead connection being soldered to the beveled edge of the plate, and specially prepared gasket of asbestos used to make the joint to the fixture. Fig. 154 shows the ordinary plate and gasket in place. Fig. 155 is an improved connection called the "Renton," and Fig. 156 is another improved connection. The gaskets of all the improved connections are of asbestos or other non-perishable material.

BRAZING.* — When two pieces of iron or steel are welded together, they are joined by making the pieces so hot that the particles of one piece will stick to those of the other, no medium being used to join them. In brazing, however, the brass acts in joining two pieces of metal together in somewhat the same manner that glue does in joining two pieces of wood. Briefly

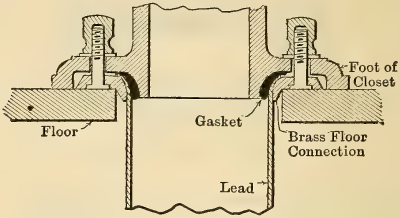


Fig. 155. "Renton" Closet Connection.

the process is as follows: The surfaces to be joined are cleaned, held together by a suitable clamp, heated to the temperature of melting brass, flux added, and the brass melted into the joint. The brass used is generally in the shape of "spelter," though brass wire or strips of rolled brass are sometimes used in place of spelter, brass wire in particular being very convenient in many

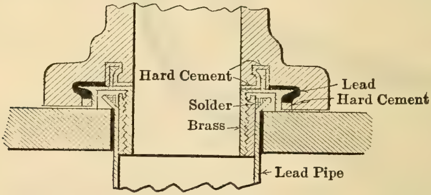


Fig. 156. Improved Closet Connection.

places. A simple example of a brazed joint is shown in Fig. 157, where a flange is brazed to the end of a small pipe. It is not necessary in this case to use any clamps, as the pieces will hold themselves together. The joint between the two should be made roughly. If a tight joint be used there will be no chance for the brass to run in. The joint should fit in spots but not all around.

* "Technical World."

Before putting the two pieces together, the surfaces to be joined should be cleaned free from loose dirt and scale. When ready for brazing the joint is smeared with a flux (one part salammoniac, six or eight parts borax) which may be added dry or put on in the form of a paste mixed with water. The joint is then heated and the spelter mixed with flux sprinkled on and melted into place. Brass wire could be used in place of the spelter in the manner indicated, the wire being bent into a ring and laid round the joint as shown. Ordinary borax may be used as a flux, although not

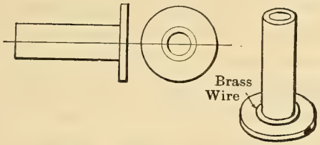


Fig. 157. Methods of brazing.

as good as the mixture used above. The heat should be gradually raised until the brass melts and runs all around and into the joint, when the piece should be lifted from the fire and thoroughly cleaned, by scraping off the melted borax and scale. It is necessary to remove the borax, as it leaves a hard, glassy scale which is particularly disagreeable if any filing or finishing has to be done to the joint. This scale may be loosened by plunging

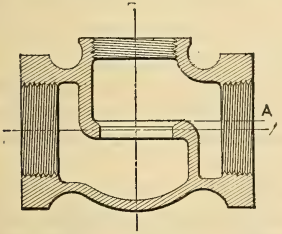


Fig. 158. Wrong Way to set Globe Valves.

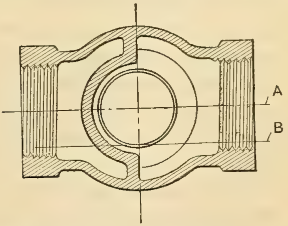


Fig. 159. Correct Way to set Globe Valves.

the work, while still red-hot, into cold water. Almost any metal which will stand the heat may be brazed.

Position of Globe Valves. — Globe valves, when possible, should be set on their side.

Fig. 158 shows a section of a globe valve set upright, which shows in case of drainage that the valve will only drain the pipe to the line *A*, or just about half empty the pipe. It also forms a dam half the height of the pipe to catch sediment.

Fig. 159 shows the same valve set on its side, and as will be seen, will drain down to the line *B* or will empty the pipe.

THE ABUSE OF VALVES.* — The following are a number of reasons why valves leak after being placed in a pipe line: —

1. We are confident that ninety per cent of all the trouble with leaky valves arises from the improper use of cement, and from the failure to remove the particles of cement, scale, chips, dirt, etc., that naturally get into the pipe while it is lying around a building and then lodge on the valve seat after steam is turned on.

When applying cement, it should be put on the male part only, for if placed on the female part, it goes through the pipe and gets on the valve seat. In any case much more cement is used than is really necessary.

If steam fitters would take pains to apply the cement as above directed, and also make sure the pipe is clean by standing it on end and striking it a few times with a hammer before putting it into place, in order to loosen any scale or dirt that may be inside, an immense amount of trouble would be avoided.

As a further precaution, it is well, when a job is started up, to open all the valves throughout the building and blow the steam through them thoroughly. After doing this properly there will be very little material in the pipes to cause trouble. After the job has been run a short time, it would be well, as an additional precaution, to clean out all the valves thoroughly.

2. It occasionally happens that threads on pipe are cut longer or smaller than standard, in which case, if the pipe is screwed into the valve, it very likely will run up against the partition and injure it.

3. In the lighter class of valves, one of the common abuses is the application of a pipe wrench on the opposite end of the valve from the end which is being screwed on the pipe. This should never be done, as it invariably springs the valve and of course causes it to leak.

4. If a light valve is put into a vise for the purpose of removing the centerpiece, the valve should certainly be clamped lengthwise.

In all cases when removing centerpiece, care should be taken to

* Set of rules given out by Crane Co.

have the disc some distance from the seat, as otherwise the disc will be forced onto the seat and some part of the valve become strained.

Never use an old, strained monkey wrench on a centerpiece, as such wrench is quite likely to squeeze the corners of centerpiece out of shape.

If found impossible to remove the bonnet or centerpiece by ordinary methods, heat the body of the valve just outside the thread with a blowtorch, or any other available means that can be applied to the body and not to the centerpiece. Then tap lightly all around the thread with a soft hammer. This method never fails, as the heat expands the body and breaks the joint made by the litharge or cement.

5. Often when a stuffing-box leaks, a steam fitter will endeavor to stop the leak by straining the stuffing-box with a large wrench, when the difficulty is due to the packing having become worn out and needing to be renewed.

6. It sometimes happens that when a valve is to be used on a header, the steam fitter will start out with a long piece of pipe that is unsupported, and, through carelessness, will allow the strain of the pipe to come on the valve, thereby springing it.

7. Serious trouble is also likely to occur in a pipe line where light valves are used through the fitter not making proper allowance for expansion and contraction and allowing the strain to be thrown on the valves. The pipe and fittings are much more rigid and stiff than the lighter brass valves, and in consequence the expansion strains will relieve themselves at the weakest point, unless otherwise provided for. A very good example of this is illustrated in most high buildings heated by steam, where it is difficult to take care of the expansion. The steam fitter will branch out of his riser with a feed pipe to radiator. The radiator will have high legs, and the air valve end usually stands close to the riser. He runs this branch (from three to six feet in length) underneath the radiator to the front end, and usually connects same to the radiator valve by a short nipple. This cross piece or branch under the radiator is supposed to take up the expansion and contraction of the riser, which may expand from one-half inch to one and one-half inches. He does not appreciate the fact that the ordinary light angle radiator valve is the most flexible of all the connections and will spring or distort itself before anything else in the branch. He makes his radiator

valve serve as a swing joint and universal connection, yet wonders why the valve leaks.

In such a building it is very difficult to provide sufficiently for this expansion, and probably the safest way to insure good work is to use, in such parts of the job, a valve of very much heavier construction, so that there will be no danger of its springing.

8. Very often, when a valve leaks, some one will stupidly undertake to tighten it by using some kind of a lever on the

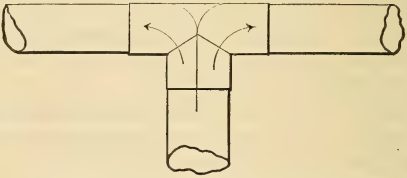


Fig. 160. Carrying Smoke to two Outlets.

wheel. This should never be done, as it will in all probability injure the valve. As the trouble undoubtedly is due to the presence of dirt in the valve, it is very much better in such cases to take the valve apart and clean the seat.

Carrying Smoke through Two Flues. — It sometimes happens that when a heating system is put into an old house there

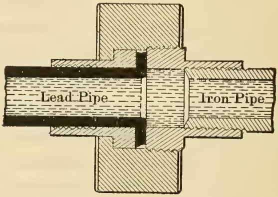


Fig. 161. Connecting Lead to Iron Pipe.

will not be a flue available for use that has sufficient area for the heater or boiler, but there may be two small flues that can be used. When such is the case run the smoke pipe of the heater or boiler up to a tee as shown by Fig. 160. Then run the two branches from the tee as shown. Put a partition in the tee as shown extending down about a foot below the lower side of the branch

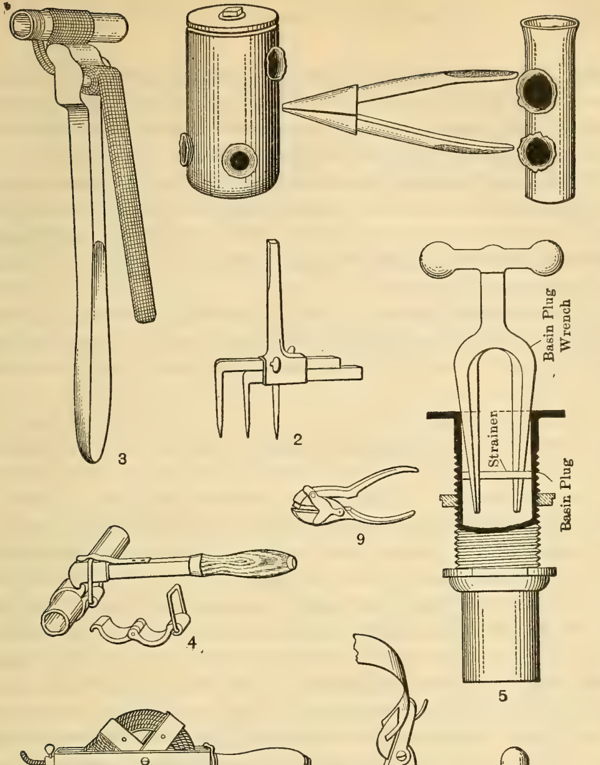


Fig. 162.

pipes. This partition will form two passages for the ascending smoke and will divide the smoke so that each flue will then draw off its equal share of the smoke, and the draught of one flue will not interfere with the draught of the other one.

To Connect a Lead and Iron Pipe. — Fig. 161 shows how a lead pipe can be connected to an iron pipe by using a union; the lead pipe is inserted in the union and swedged over as shown, then the union is screwed together, compressing the lead flange and making a tight joint.

Labor-saving Tools. — Fig. 162 shows a number of labor-saving tools, which every plumber should keep on hand; on one job of plumbing they will often save their cost, in the amount of time and labor saved.

1 is an expanding plier, and is used in place of the turning pin for swedging out lead pipe or openings for making a wipe joint. 2 is a washer cutter to be used in the brace, and will cut washers of any desired size. 3 and 4 are wrenches for turning brass or nickle-plated pipe without scratching or disfiguring the pipe. It is a good idea to wrap a piece of paper around the pipe before applying the wrench. 5 is a basin plug wrench for holding the basin plug while the connection is screwed up below. Holding the plug in this manner prevents it from becoming loose from the basin when turning up the lower connection. 6 is a flexible auger used for cleaning out stoppages in pipe, etc. 7 is also an auger made especially for cleaning out closets as shown. 8 is an air compressor, made of rubber and wood; it is provided with a long handle and used for cleaning out water closets, traps and soil pipe, scrubbing water closets and wash bowls, forcing stoppage out of waste pipes, wash bowls, urinals, etc. 9 is a crimper for crimping the ends of stove and hot air pipe. 10 is the double or pipe shears for cutting round stove or hot air pipes.

Running Lead Joints. — When running hub and spigot joints with lead do not resort to the old fashioned method of using clay as a dam; asbestos joint runners are now made and will save their cost in a very short time in labor saved; one of these clamps can be clamped around the pipe and the joint run in less time than it would take to put the clay in place by the old method.

Setting Pumps. — When setting a pump locate it as near the water supply as possible; the atmospheric pressure is what forces the water into the pump, consequently the lower the pump and

shorter the lift, the faster and with greater efficiency will the water be delivered to the pump.

WHERE RUST JOINTS SHOULD BE USED. — Rust joints should be used on cast-iron pipes through which very hot water or steam is to be carried, but should not be used on any closed part of a house drainage system; see page 467 for method of making a rust joint.

USE OF STILLSON AND MONKEY WRENCHES. — Use a Stillson wrench only where it is intended to be used, and a monkey wrench ditto. Nothing spoils the looks of a job of piping more than to see union or other flat sided connections disfigured by using a Stillson wrench on them.

PLUMBING RULES.

The following rules regarding plumbing are taken from the Philadelphia Building Code:

Main drain to be connected with street sewer.

When private sewer is necessary, plans must be approved by Board of Health.

Joint drain not to be laid in cellars.

Rule 10. The main drain of every house or building shall be separately and independently connected with the street sewer, where one is provided; and where there is no sewer in the street, and it is necessary to construct a private sewer to connect with one on an adjacent street, such plans may be used as may be approved by the Board of Health; but in no case shall a joint drain be laid in cellars parallel with street or alley.

Material to be used in underground house-drains.

All house-drains laid beneath the ground inside of buildings or beneath the cellar floor shall be of plain, extra-heavy cast-iron pipe, with well leaded and calked joints, or of wrought iron, with screw joints made with a paste of red lead and treated to prevent corrosion.

Material to be used in other drain- or soil-pipes.

All other drains or soil-pipes connected with the main drain, or where the main drain pipe is above the cellar floor, shall be of plain cast-iron pipe, or of wrought-iron pipe with screw joints made with a paste of red lead and treated to prevent corrosion.

Outside of the buildings, where the soil is of sufficient solidity for a proper foundation cylindrical terra-cotta pipes of the best quality, free from flaws, splits, or cracks, perfectly burned, and well glazed over the entire inner and outer surfaces may be used, laid on a smooth bottom, with a special groove cut in the bottom of trench for each hub (in order to give the pipe a solid bearing on its entire length) and the soil well rammed on each side of the pipe. The spigot and hub ends shall be concentric..

Terra-cotta drain-pipes may be used outside of buildings under certain conditions.

The space between the hub and pipe shall be thoroughly filled with the best cement mortar, made of equal parts of the best American natural cement and bar sand thoroughly mixed dry, and water enough afterward added to give it proper consistency. The cement must be mixed in small quantities at a time and used as soon as made. The joints must be carefully wiped and pointed, and all mortar that may be left inside thoroughly cleaned out and the pipe left clean and smooth throughout, for which purpose a swab shall be used.

Space between hub and pipe to be filled with cement mortar.

Joints to be properly finished.

No tempered-up cement shall be used. A straight-edge shall be used, and the different sections shall be laid in perfect line on the bottom and sides; but in no case shall terra-cotta pipes be permitted within five (5) feet of any foundation-wall, or for extension to connect with rain-water conductors, surface or air inlets.

Quality of cement.

Terra-cotta pipes not to be within 5 feet of foundation-wall, nor used for extensions.

Note.—After the test has been approved by the inspector, iron drain- or soil-pipes may be tar-coated. But in no case shall any coating be applied to cast-iron soil- or drain-pipes until test has been applied and approved by the inspector.

Coating of pipes not to be done until after approval by inspector.

Rule 11. The house-drain shall be not less than four (4) inches, nor more than ten (10) inches in diameter, and the fall shall not be less than one-half ($\frac{1}{2}$) an inch to the foot, unless by special permission of the Board of Health; it shall be laid in a trench cut at a uniform grade, or it may be constructed along the foundation-

Construction of house-drains.

walls above the cellar floor, resting on nine (9) inch brick piers laid in cement mortar (said piers to be not more than seven (7) feet apart) and securely fastened to said walls; no tests shall be made by the inspector until said pipes are secured as above described.

Arrangement of house-drains.

Rule. 12. The arrangement of soil- and waste-pipes shall be as direct as possible. All changes in direction on horizontal pipes shall be made with Y branches, one-sixteenth ($\frac{1}{16}$) or one-eighth ($\frac{1}{8}$) bends.

Location of main trap of house-drain.

Rule 13. The house-drain shall be provided with a horizontal trap, placed immediately inside the cellar wall nearest to the sewer, or at the curb. The trap shall have a hand-hole, for convenience in cleaning, the cover of which shall be properly fitted and the joints made air-tight.

Main trap to have a hand-hole.

Note.—If the trap and the main drain is placed inside of the cellar wall, there shall be no clear-out between the water seal of the trap and the sewer.

Location of fresh-air inlets in drains.

Rule 14. There shall be an inlet for fresh air entering the drain just inside the water seal of the main trap, and also at the rear of the system, when the vertical line of soil-pipe is located in the central part of the building and the main fresh-air inlet is deemed insufficient to ventilate the entire system. Said inlets shall be at least four (4) inches in diameter, leading to the outer air and opening at any convenient place, with an accessible clean-out. Where air inlets are located off the footway, on grass plots, lawns, etc., they shall extend not less than six (6) nor more than fifteen (15) inches above the surface of the ground and be protected by a cowl securely fastened with bolts.

Relieving arch required when drain-pipe passes through a new foundation-wall.

Rule 15. Where the drain passes through a new foundation-wall a relieving arch shall be built over it with a two (2) inch clearance on either side.

Rule 16. Every vertical soil-pipe shall extend at least two (2) feet above the highest part of the

building or contiguous property, and shall be of undiminished size, with the outlet uncovered except with a wire guard. Such soil-pipe shall not open near a window nor an air-shaft ventilating living-rooms.

Construction of vertical soil- or waste-pipes.

Rule 17. Every branch or horizontal line of soil-pipe to which a group of two (2) or more water-closets is to be connected, and every branch line of horizontal soil-pipe eight (8) feet or more in length, to which a water-closet is to be connected, shall be ventilated, either by extending said soil-pipe, undiminished in size, to at least two (2) feet above the highest part of the building or contiguous property, or by extending said soil-pipe and connecting it with the main soil-pipe above the highest fixture, or by a ventilating pipe connected to the crown of each water-closet trap, not less than two (2) inches in diameter, which shall be increased one-half ($\frac{1}{2}$) an inch in diameter for every fifteen (15) feet in length, and connected to a special air-pipe, which shall not be less than four (4) inches in diameter, or by connecting said ventilating pipe with the main soil-pipe above the highest fixture.

Branch or horizontal soil-pipes to which water-closets are connected to be ventilated; manner of such ventilation.

Rule 18. Where a separate line of waste-pipes is used, not connected with sewer-pipes, it shall also be carried two (2) feet above the highest part of the building or contiguous property, unless otherwise permitted by the Board of Health. But in no case shall a waste-pipe connect with a rain-water conductor.

Construction of waste-pipes not connected with sewer-pipes.

Waste-pipe not to connect with rain-water conductor.

Rule 19. There shall be no traps, caps, or cowls on soil- and waste-pipes which will interfere with the system of ventilation.

No obstruction to ventilation to be placed on soil or waste-pipes.

Rule 20. All soil-, waste-, anti-siphon pipes and traps inside of new buildings, and of the new work in old buildings, and also of the entire system when alterations are made in old buildings, and the owner or agent of said building or buildings shall have contracted to have the entire drainage system tested, shall have openings stopped and a test of not less than three (3) pounds atmospheric pressure to the square inch applied.

Test of not less than 3 pounds pressure per square inch to be applied to drain-pipes and traps.

Drain-pipes and traps to be easily accessible when practicable.

When drain-pipes and traps are not easily accessible, heavy pipe to be used.

Rule 21. The drain-, soil-, and waste-pipes, and the traps, shall, if practicable, be exposed to view for ready inspection at all times, and for convenience in repairing. When placed within walls or partitions and not exposed to view, or not covered with woodwork fastened with screws so as to be readily removed, or when not easily accessible, extra-heavy pipes shall be used at the discretion of the Board of Health.

Drainage work not to be covered or concealed until inspected.

Notice to Board of Health.

Final inspection.

Name of master plumber to be placed on delinquent list for violation of rules of Board of Health.

Criminal prosecution in case a delinquent shall do any drainage work.

Rule 22. No drainage work shall be covered or concealed in any way until after it has been examined and approved by a house-drainage inspector, and notice must be sent to the Board of Health, in writing, when the work is sufficiently advanced for such inspection; and immediately on the completion of the work application must be made for final inspection. The failure on the part of a master plumber to make said application for final inspection, or the violation of any of the rules of the Board of Health in the construction of any drainage work, and failure to correct the fault after notification, will be deemed sufficient cause to place his name on the delinquent list until he has complied with said rules and regulations. Any attempt on the part of a master plumber to construct or alter a system of drainage during the time his name appears on said delinquent list will subject him to criminal prosecution.

Quality and weight of drain- and soil-pipes.

Rule 23. All drain and anti-siphon pipes of cast iron shall be sound, free from holes, and of a uniform thickness, and shall conform to the following relative weights:

Standard.			Extra Heavy.		
In.		Lbs.	In.		Lbs.
2 pipe,		4 per foot.	2 pipe,		5½ per foot.
3	"	6 "	3	"	9½ "
4	"	9 "	4	"	13 "
5	"	12 "	5	"	17 "
6	"	15 "	6	"	20 "
7	"	20 "	7	"	27 "
8	"	25 "	8	"	33½ "
10	"	35 "	10	"	45 "
12	"	45 "	12	"	54 "

Rule 24. All drain and anti-siphon cast-iron pipes shall have the weight per foot and the name of the manufacturer cast on the exterior surface, directly back of the hub of each section, in characters not less than one-half ($\frac{1}{2}$) inch in length.

Name of manufacturer and weight per foot to be cast on drain- and soil-pipes.

Rule 25. Lead waste-pipes may be used for horizontal lines that are two (2) inches or less in diameter, and shall have not less than the following prescribed weights:

When lead waste-pipes may be used.

1 inch pipe,	2 lbs.	0 oz.
$1\frac{1}{4}$ " "	2 "	8 "
$1\frac{1}{2}$ " "	3 "	8 "
2 " "	4 "	0 "

Weight of lead pipes.

Rule 26. Lead bends or traps for water-closets shall not be less than one-eighth ($\frac{1}{8}$) of an inch in thickness.

Thickness of lead bends or traps for water-closets.

Rule 27. Waste-pipes from wash-basins, sinks, and bath-tubs shall not be less than one and one-quarter ($1\frac{1}{4}$) inches in diameter, and wash-tray waste-pipes not less than one and one-half ($1\frac{1}{2}$) inches in diameter.

Diameter of water-pipes from wash-basins, sinks, bath-tubs, and wash-trays.

Rule 28. All joints in cast-iron drain-, soil-, and waste-pipes shall be so calked with oakum and lead, or with cement made of iron filings and salammoniac, as to make them gas-tight.

Joints in cast-iron drain-pipes to be calked.

Rule 29. All connections of lead with iron pipe shall be made with a brass ferrule not less than one-eighth ($\frac{1}{8}$) of an inch in thickness, put in the hub of the iron pipe and calked in with lead, except in cases of iron water-closet traps or old work, when drilling and tapping is permitted. The lead pipe shall be attached to the ferrule by a wiped solder joint.

Connections of lead with iron pipe to be made with a brass ferrule; how connection to be made.

Rule 30. All connections of lead pipe shall be by wiped solder joints.

Connections of lead pipe to be by solder joints.

Rule 31. Every water-closet, sink, basin, wash-tray, bath, and every tub or set of tubs, shall be separately and effectually trapped.

Water-closets, sinks, etc., to be separately trapped.

Rule 32. The trap must be placed as near the fixture as practicable. All waste-pipes shall be provided with strong metallic strainers. All

Location of traps.

Strainers.

drains from hydrants shall be trapped and in a manner accessible for cleaning out.

Drains from hydrants.

Rule 33. Traps of fixtures shall be protected from siphonage. All anti-siphon pipes shall be carried up and through the roof or connected with the main soil-pipes above the highest fixture.

Traps to be protected from siphonage.

Rule 34. Every anti-siphon pipe shall be of lead, of galvanized gas-pipe, or of plain cast-iron pipe. Where these pipes go through the roof they shall extend two (2) feet above the highest part of the building or contiguous property; they may be combined by branching together those which serve several traps. These pipes where not vertical must always be a continuous slope, to avoid collecting water by condensation.

Construction of anti-siphon pipes.

Material to be used in anti-siphon pipes.

Construction of same.

Rule 35. All drip- or overflow-pipes from safes under wash-basins, baths, urinals, water-closets, or other fixtures shall be by a special pipe run to an open sink outside the house or some conspicuous point; and in no case shall any such pipe be connected with a soil-, drain-, or waste-pipe.

Construction of drip- or overflow-pipes.

Rule 36. No waste-pipe from a refrigerator or other receptacle in which provisions are stored shall be connected with any drain-, soil-, or other waste-pipe. Such waste-pipes shall be so arranged as to admit of frequent flushing, and shall be as short as possible.

Waste-pipe from refrigerator, etc., not to be connected with any drain-pipe.

Rule 37. The overflow-pipes from tanks and the waste-pipes from refrigerators shall discharge into an open fixture properly trapped.

Discharge of overflow from tanks and refrigerator waste-pipes.

Rule 38. All water-closets within buildings shall be supplied with water from special tanks or cistern which shall hold not less than eight (8) gallons of water when up to the level of the overflow-pipe for each closet supplied, excepting automatic or siphon tanks, which shall hold not less than five (5) gallons of water for each closet supplied; the water in said tanks shall not be used for any other purpose. The flushing-pipe of all tanks shall not be less than one and one-quarter ($1\frac{1}{4}$) inches in diameter.

Water-closets to be supplied with water from flushing-tanks.

Capacity of such tanks.

Size of flushing-pipe.

Rule 39. No closet, except those placed in the yard, shall be supplied directly from the supply pipes.

Water-closets not to be supplied directly from main.

Rule 40. A group of closets may be supplied from one tank, but water-closets on different floors shall not be flushed from one tank.

Supplying different closets from same tank.

Rule 41. Water-closets, when placed in the yard, shall be so arranged as to be conveniently and adequately flushed, and their water-supply pipes and traps shall be protected from freezing by placing them in a hopper-pit, at least three and one-half ($3\frac{1}{2}$) feet below the surface of the ground, the walls of which shall be of brick or stone laid in cement mortar. The water-pipe from the hopper stopcock shall be conveyed to the drain through a three-eighths ($\frac{3}{8}$) inch pipe, properly connected.

Yard water-closets to be adequately flushed.

Protection of supply pipes to same from freezing.

Rule 42. The inclosure of the yard water-closet shall be ventilated by slatted openings, and there shall be a trap-door in the floor of sufficient size for access to the hopper-pit.

Inclosure of yard water-closets to be ventilated and have trap-door in floor.

Rule 43. Water-closets must not be located in the sleeping-apartments of any building, nor in any room or apartment which has not direct communication with the external air either by a window or an air-shaft having an area to the open air of at least four (4) square feet.

Water-closets not to be located in sleeping-apartments nor in apartment without communication with external air.

Rule 44. The containers of all water-closets shall be supplied with fresh air and properly ventilated, as approved by the Board of Health.

Containers of water-closets to be ventilated.

Rule 45. All water-closets within a building using lead connections shall have a cast-brass flange not less than three-sixteenths ($\frac{3}{16}$) of an inch in thickness (fitted with a pure-rubber gasket of sufficient thickness to insure a tight joint) bolted to the closet.

Lead connections to water-closets within a building.

Rule 46. Where latrines are used for schools they shall be of iron, properly supplied with water, and located in the yard at least twenty (20) feet from the building when practicable.

Construction of latrines for schools.

Rule 47. Rain-water conductors shall be connected with the house-drain or sewer and be

Rain-water conductors to be connected

provided with a trap the seal of which shall be not less than five (5) inches. Said trap shall have a hand-hole for convenience in cleaning, the cover of which shall be made air-tight.

with house-drain or sewer and provided with trap; trap to have hand-hole.

Rain conductors shall not be connected outside of the main trap, nor used as soil-, waste-, or vent-pipes; nor shall any soil-, waste-, or air-pipe be used as a rain conductor, and if placed within a building shall be of cast iron with leaded joints.

Rain conductors not to be connected outside of main traps, nor used as soil- or waste-pipes.

Rule 48. No steam exhaust or waste from steam-pipes shall be connected with any house-drain or soil-pipe.

Steam-exhaust pipes not to be connected with drain-pipes.

Rule 49. No privy vault or cesspool for sewage shall hereafter be constructed in any part of the city where a sewer is at all accessible.

Privy-vault or cesspool not to be constructed where a sewer is accessible.

Rule 50. No connection from any cesspool or privy-well shall be made with any sewer, nor shall any water-closet or house-drainage empty into a cesspool or privy-well.

Connection of cesspool or privy-well not to be made with sewer.

Water-closet or house drainage not to empty into cesspool or privy-well.

Rule 51. In rural districts waste-pipes from buildings may be connected with cesspools constructed for that special purpose, properly flagged or arched over, and not water-tight, by special permission of the Board of Health.

Waste-pipes may be connected with cesspools in rural districts.

Rule 52. Privy-vaults must be constructed as follows: Each building situate on an unsewered street must have a privy-vault not less than four (4) feet in diameter and ten (10) feet deep in the clear, lined with hard brick nine (9) inches in thickness, laid in cement mortar, and proved to be water-tight.

Construction of privy-vaults.

Rule 53. Privy-vaults shall not be located within two (2) feet of party lines, or within twenty (20) feet of a building when practicable; and before any privy-vault shall be constructed, application shall be made and a permit for same issued by the Board of Health.

Privy-vaults not to be located within 2 feet of party lines or 20 feet of a building.

Permit for construction of privy-vault required.

Rule 54. No opening will be permitted in the drain-pipe of any building for the purpose of draining a cellar, unless by special permission by the Board of Health.

No opening to be in drain-pipe for draining cellar unless by permission.

Rule 55. Cellar-drains shall be constructed as follows: By a system of French drains, or field tile, to a catch-basin, flagged over; the outlet pipe shall be properly trapped and connected with the house-drain, and shall also be provided with a back-pressure valve or stop-cock the required size.

Construction of cellar drains.

Terms Used.

The term " private sewer " is applied to main sewers that are not constructed by and under the supervision of the Department of Public Works.

The term " house-sewer " is applied to that part of the main drain or sewer extending from a point five feet outside of the outer wall of a building, vault or area to its connection with public sewer, private sewer or cesspool.

The term " house drain " is applied to that part of the main horizontal drain and its branches inside the walls of the building, vault or area, and extending to and connecting with the house sewer.

The term " soil-pipe " is applied to any vertical line of pipe extending through the roof, receiving the discharge of one or more water-closets, with or without other fixtures.

The term "waste-pipe" is applied to any pipe extending through roof, receiving the discharge from any fixtures except water-closets.

The term "vent-pipe" is applied to any special pipe provided to ventilate the system of piping, and to prevent trap siphonage and back pressure.

PART V.

SOME EXAMPLES OF MODERN PLUMBING. MODERN SPECIFICATIONS. MISCELLANEOUS RECEIPTS. MENSURATION AND MENSURATION TABLES. ODDS AND ENDS FOR THE NOON HOUR. WAGE TABLES.

SOME EXAMPLES OF MODERN PLUMBING.

Figs. 163–166 * show plumbing work done in the addition to the Raleigh Hotel, Washington, D. C. The specifications for this work were as follows:

Sewer Connections. — Make connections with the street sewer for one house sewer, 8 inches in diameter. To be of extra heavy cast iron and to have a running trap of same caliber as the pipe, complete with "cleanouts" on either side of the seal fitted with brass screw cap ferrules caulked into trap. This trap, with proper fresh air inlet to house sewer, is to be of extra heavy cast iron and be located according to the plumbing regulations. Provide proper connection with the 8-inch house sewer for the blow-off and drip tank discharges.

Drainage System. — The drainage system for the building will be connected with the house sewer directly and will be chiefly of cast iron extra heavy piping, or regulation sizes. Carry in from the house trap the 8-inch trunk line for house drain, to be hung from the ceiling of basement by suitable hangers secured to the floor beams. Place upon said line proper sized and located "cleanouts" with caps. All changes in direction of drain pipes are to be made by means of Y branches and one-eighth bends, and the entire horizontal runs are to be uniformly graded one-quarter of an inch per foot.

Leader Drains. — Carry up from the respective branches on house drain the various lines of leaders; each line where

* The following figures showing examples of Modern Plumbing have been taken by permission from The Plumbers' Trade Journal, New York.

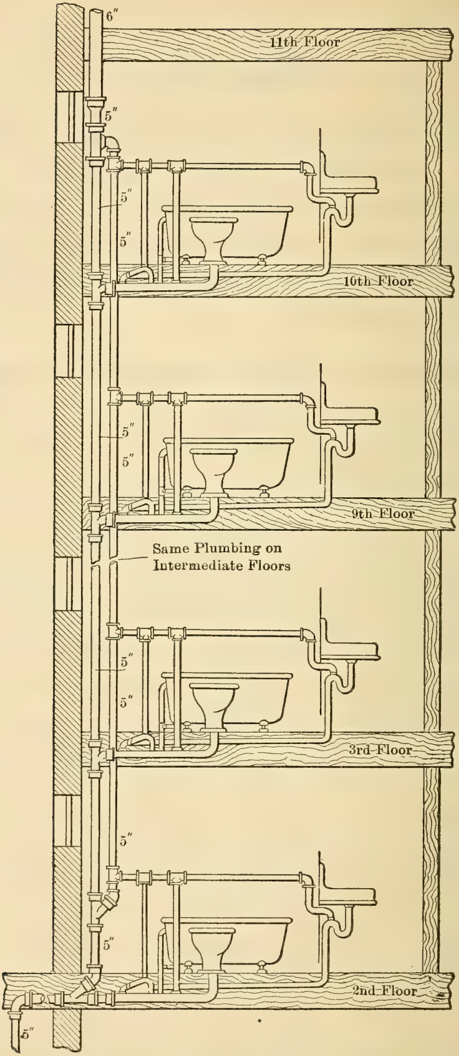


Fig. 163. Bath Rooms in the Raleigh Hotel, Washington, D. C.

entering the said drain to have a running trap of full caliber of leader provided with brass screw cap ferrules. There will be four (4) lines of leaders with branches as follows: No. 1 — 3

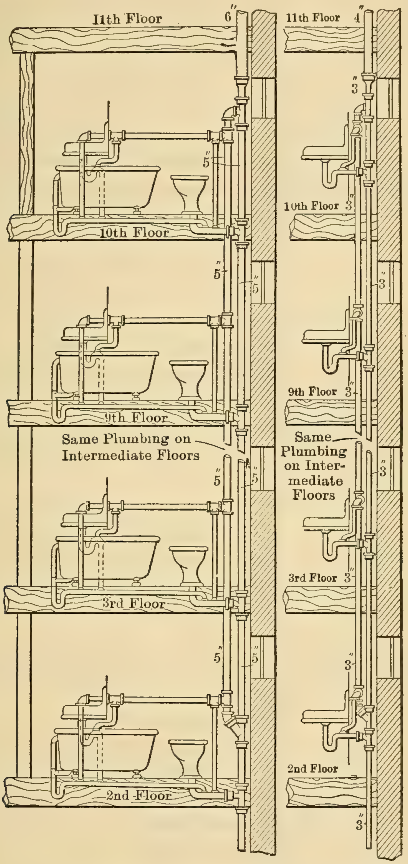


Fig. 164. Plumbing Work in the Raleigh Hotel, Washington, D. C.

inches diameter, serving roof of dome and having 3-inch branches near the third and eleventh and main cornice levels. No. 2 — 3 inches diameter, having similar run and branches. No. 3 — 5 inches diameter, serving the north court and roof at about 4 feet

above second floor level and having a 3-inch branch for north court. No. 4 — similar to No. 3, serving east court and roof. Provide for each leader connection, whether outside or inside, the necessary brass ferrules screwed into the pipe and made ready to receive the copper connections made by the sheet metal contractor; the leaders connecting with the roof directly to be carried to within 6 inches of the point of outlet.

Soil and Waste Upright Lines. — Carry up from the house drain the various upright lines and branches for soil and waste pipes to serve all fixtures throughout the building. Each line to have the requisite number of branches to serve each group of fixtures, the said branches being made by means of Y's and eighth bends, as may be required.

Vent Upright Lines. — Carry up the various lines of vent and back air pipes, of galvanized wrought iron, the same having the necessary T branches to serve each group of fixtures, and being connected at the foot into the nearest soil or waste line, so as to discharge rust or condensed water accumulations. Where these uprights serve fixtures upon six or more stories, the same must extend independently through the roof, otherwise it may be tapped into the soil or waste upright above the highest fixture upon that line.

Pipes above the Roof. — Where the various pipes pass through the roof they are to be carried to a height of not less than four (4) feet above the main roof level, or as shown on plans.

The plumber is to provide the ferrule attached to the pipe and the copper flanges and collars, all made ready for the roofing contractor.

Pipes and Fittings. — All cast iron pipes and fittings to be of extra heavy patterns and of uniform thickness, sound, cylindrical, and painted outside; all joints to be made with picked oakum and molten lead, well caulked. All the piping for waste, vent and leader line of 3-inch diameter and upward shall be of the best quality of wrought iron or steel, lap-welded tubing of standard weights. All vertical lines to be perfectly plumb and horizontal lines to be uniformly graded.

Weights of Pipes.— Cast Iron:	Wrought Iron: "Standard."
4 in. dia., 13 lbs. per linear ft.	$1\frac{1}{2}$ in. dia., 2.68 lbs. per linear ft.
5 in. dia., 17 lbs. per linear ft.	2 in. dia., 3.61 lbs. per linear ft.
6 in. dia., 20 lbs. per linear ft.	
8 in. dia., $33\frac{1}{2}$ lbs. per linear ft.	

CONNECTIONS. — All connections between cast and wrought iron pipe to be made by means of caulked and screwed fittings; between wrought and wrought iron, to be made by means of screwed joints with red and linseed oil; between wrought iron and lead pipes by means of screwed brass ferrules and soldering nipples with wiped lead joints, and between brass or brass and iron, by means of screwed connections. All connections must be standard in size, weight and finish, and all joints must be absolutely gas- and water-tight. The short lead bends for water closets' traps must be soldered firmly to the brass floor plates and the joints between trap and plate must be made with red lead and linseed oil. For wash basins, baths, and other fixtures having traps two inches or under in diameter, the connections are to be made by means of combination waste and vent connections, wherever possible.

TESTS. — Both drainage systems are to be properly tested by a pressure test in the presence of the District Inspector of Plumbing, said pressure to be made by air or water, and the whole system to be proved perfectly satisfactory before any fixture is connected to the same.

WATER SUPPLY. — Will be connected with present pressure

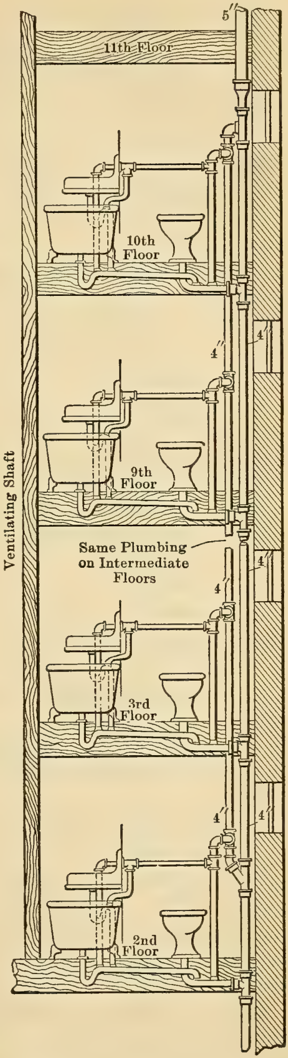


Fig. 165. Line of Nine Bath Rooms in the Raleigh Hotel.

system. The water supply pipes throughout to be of best manufacture of wrought iron or steel water tubing and of weights hereinafter scheduled. All fittings to be of extra heavy cast iron heavily threaded on to the piping, all joints being made by means of red lead and linseed oil, and all made perfectly watertight. The branches from each main to be proper sizes to fully supply water to each and every fixture, the supplies to which are to be as follows: Water closet cisterns, $\frac{1}{2}$-inch pipe; baths, $\frac{3}{4}$-inch pipe; wash basins, $\frac{1}{2}$-inch pipe; urinal cisterns, $\frac{1}{2}$-inch pipe.

Valves. — All globe valves required for this work to be of brass with soft valve seats and to be of Fairbanks or Jenkins patterns (or equally good and approved by the engineer) and all are to have metal or wood handles as may be required. Gate valves may have iron bodies but otherwise to be of brass.

Street Washer. — Provide and fit up where directed on front wall, a polished brass hose cock and nozzle, supplied through $\frac{3}{4}$-inch galvanized iron pipe from street pressure line in basement, having stop and waste cock just inside of wall.

Pipe Sleeves and Trough. — Where water pipes pass through the first story, they are to have wrought iron sleeves or galvanized sheet iron chases of sizes to permit of easy withdrawal of pipes, without disturbance to the building. Likewise where water supply pipes cross over the first story rooms, provide for the same lead lined wooden troughs with covers and arranged to drain into the pipe sleeves.

Finish for Exposed Pipes, etc. — The painting of pipes where exposed will be done by other parties, but the plumber is to cover such hot or cold water pipes, that may require protection, with same kind of asbestos-magnesia sectional covering as will be used by the heating contractor (viz., Valleau Costigan). This covering to be complete with canvas, bands, etc. All pipes of every description, where passing through floors or walls, are to have sheet metal sleeves and neat ceiling or wall flanges of nickel-plated metal. All flush pipes from cisterns are to be seamless drawn brass tubing heavily nickel plated. All valves exposed in bath or toilet rooms to be heavily nickel plated, otherwise they are to be brass finished.

Marble Work and Fittings. — Provide for all wash basins throughout countersunk and moulded slabs, $1\frac{1}{4}$ inches thick with moulded backs and ends 1 inch thick, 12 inches high.

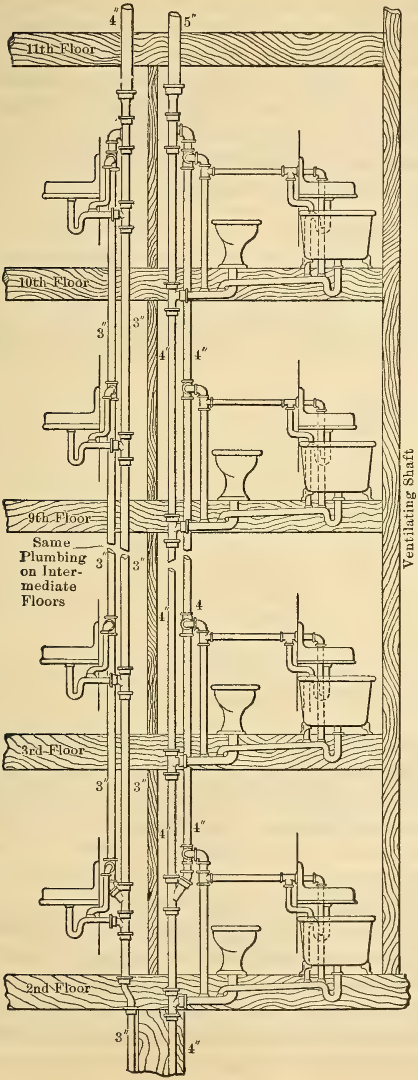


Fig. 166. Sectional View showing Line of Nine Bath Rooms and Lavatories in the Raleigh Hotel.

Nickel-plated legs to be provided for slabs where required. All urinals to have sides and backs as shown, 5½ feet high and 1 inch thick and 1¼-inch platforms countersunk and 1-inch capping. All the above to be of first quality light-veined Italian marble, highly polished. All the above to be carefully cut and polished and set in best manner, using silver-plated screws where required. Provide all clamps and standards for wash basins and all other metal fittings required for setting marble.

SCHEDULE OF FIXTURES:

Story.	Height.	W. Clos.	W. Bas.	Baths.	Urin.
11	....	2	3	....	2
10	10½	6	8	6	0
9	10½	6	8	6	0
8	11½	6	8	6	0
7	11½	6	8	6	0
6	11½	6	8	6	0
5	11½	6	8	6	0
4	11½	6	8	6	0
3	11½	6	8	6	0
2	13½	6	8	6	0
1	18	9	5	0	1
Bas.	11	—	—	—	—
		65	80	54	3

SUMMARY. — Water closets, 65; wash basins, 80; baths, 54; urinals, 3.

WATER CLOSETS. — Provide the water closets throughout the building; be all porcelain of the "Siphon" shape, approved by engineer, having hardwood cisterns, seats and covers, nickel plated fittings and pipings. The plumber is to set the same complete with perfect connections to the waste and vent pipes. Water supply to cistern to be ¾-inch galvanized iron pipe, controlled by nickel-plated ¾-inch globe valves.

BATHS. — Provide the baths throughout the building; to be of porcelain lined with rolled rim, having legs to match tub and to be complete with nickel-plated high supply fixtures combined with Unique waste, and are to be approved by the engineer. The plumber is to set same complete with proper connections to the waste and vent pipes by means of 2-inch brass trap with trap

screw vented beneath the floor. Supply with hot and cold water through $\frac{3}{4}$-inch galvanized iron pipe.

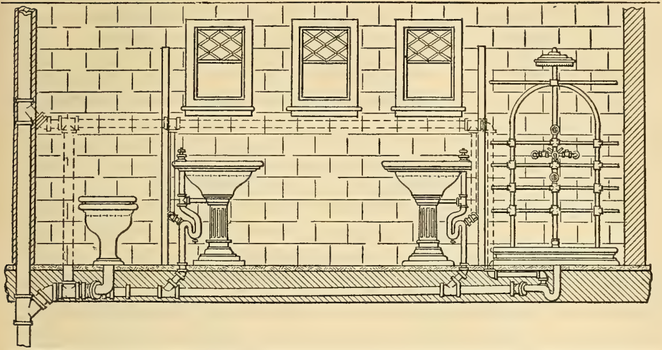


Fig. 167. Lavatories, Water Closet and Shower Bath in Bath Room of the Morgan Residence.

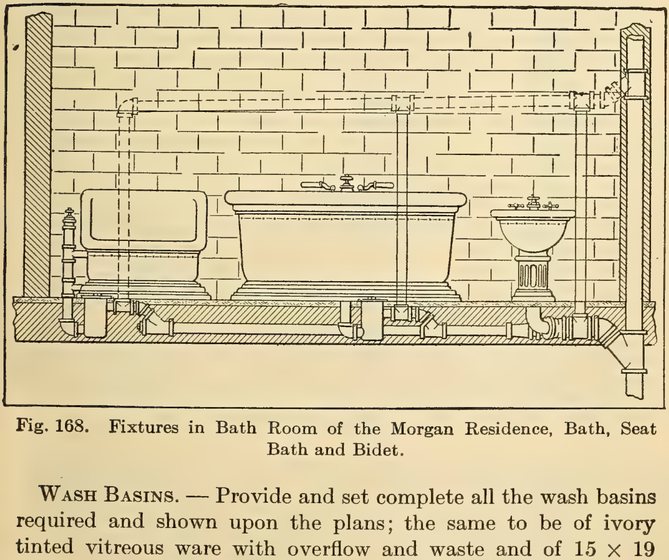


Fig. 168. Fixtures in Bath Room of the Morgan Residence, Bath, Seat Bath and Bidet.

Wash Basins. — Provide and set complete all the wash basins required and shown upon the plans; the same to be of ivory tinted vitreous ware with overflow and waste and of 15 × 19 inches oval pattern; waste through $1\frac{1}{2}$-inch nickel plated brass

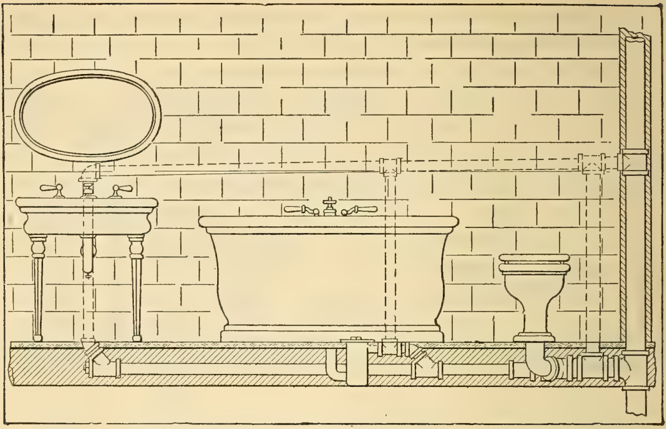


Fig. 169. Sectional View of a Bath Room in the Morgan Residence.

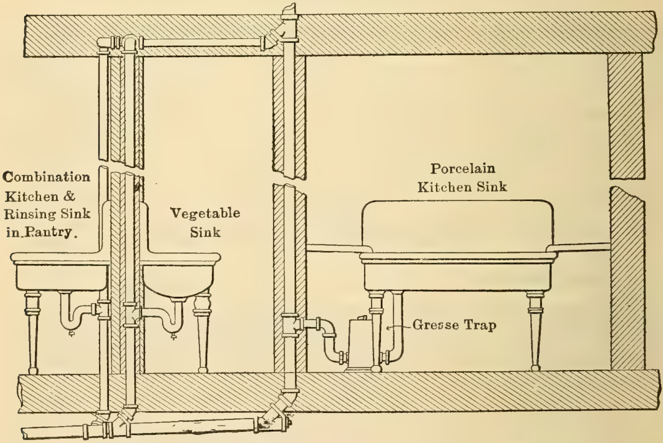


Fig. 170. Group of Kitchen Fixtures in the Morgan Residence.

trap with trap screw, and supply hot and cold water through ½-inch galvanized iron pipes. The basin fixtures to be nickel plated with Unique waste and Mott's Low-down "Fuller" pattern basin cocks. Support the slabs by nickel-plated brass legs of neat design approved by engineer.

Urinals. — Provide and fit up where required and shown on eleventh story plans, three urinals of the Newport pattern in vitreous porcelain, with trap and inlet combined. Provide for same hardwood flushing cisterns with chain and pull complete. Waste through 2-inch combination waste and vent connection and supply cistern through $\frac{1}{2}$-inch galvanized iron pipe controlled by $\frac{1}{2}$-inch nickel-plated globe valve.

Note. — Provide air chambers for each fixture or group of same as may be required.

Samples of Fixtures, etc. — The contractor is to submit samples of all fixtures and apparatus to the engineer for his approval, before order for same is placed.

Gas Piping. — Provide and run the requisite line of gas risers to supply gas to the public halls, as required by the rules of the fire department. Said lines to be of proper sized pipe for ample supply to each outlet and arrange same in the basement for meter. Each riser to be controlled by a brass stop-cock and the entire system to be graded so as to drain back to the meter. All materials to be of the best quality and the system to be tested perfectly gas-tight.

Figs. 167 to 170 show methods used in installing the plumbing in the residence of W. H. Morgan, Alliance, Ohio, and are very good examples of modern plumbing.

Figs. 171 to 178 show the plumbing work as installed in the Burden Mansion, No. 7 East 91st St., New York. The work was done under the following specifications:

This part of the work was to be installed and guaranteed by the contractor for one year from the date of final inspection. The accompanying plans and specifications will give the reader an idea of the work installed:

Cast Iron Pipe. — 41. All underground pipes must be of extra heavy cast iron of the sizes, location and arrangement shown on plans. 42. After being placed in position and tested, all underground pipes to be painted by the plumbing contractor two coats of asphalt varnish or Prince's metallic paint, as may be directed.

Wrought Iron Pipe. — 43. All soil, waste and vent pipes, and the house drain where above ground, must be of galvanized wrought iron pipe, of the sizes, location and arrangement shown on plans. Drainage fittings to be malleable. 44. The connection between wrought iron and cast iron pipe to be made by

screwing on to the end of the wrought iron pipe a 1-inch ring to form a spigot which may be properly calked into the hub of the cast iron pipe or fitting. 45. All branch, waste and vent pipes not directly exposed at fixtures shall be galvanized wrought iron.

LEAD. — 46. The water closet bends, the traps for baths and their short waste and vent branches are to be of lead. Where

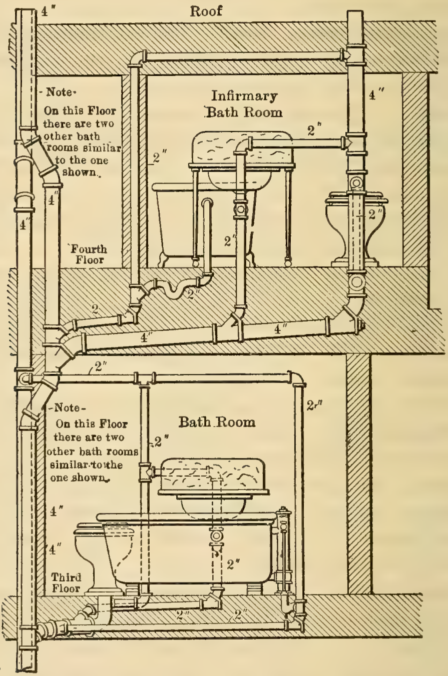


Fig. 171. One of the Bath Rooms in the Burden Residence.

lead is to be covered in contact with cement or other filling material it must be painted as specified for underground cast iron pipe and neatly wrapped in tarred paper wired on with copper wire. 47. Sheet lead must be six (6) pound lead.

Brass. — 48. All exposed work on supply and waste pipe about fixtures to be polished brass of iron pipe standard, except where otherwise specified in detail.

Plated Work. — 49. All exposed brass to be nickel plated, except where otherwise specified in detail; to be the best quality heavy plate on polished brass and warranted; "N. P." where used in this specification means "nickel-plated brass." Where screws, bolts, washers, etc., are required in connection with brass, marble or slate work, they must be N. P., and all bolts, fastenings, hinges, straps, etc., for seats and marble or slate work to be N. P. unless other material is specified.

Cleanouts. — 53. Provide and set fittings for cleanouts at the end of all branches of drains and soil and waste pipe at points of change in direction, and on traps, etc., as shown on plans or as directed. All such cleanouts to be "Y" or "T" branches or trap hubs, same size as pipe and closed, gas-tight with special extra heavy cast brass plugs. All iron drain and leader traps, etc., must have hand-hole cleanouts. Make cleanouts accessible. 54. The brass caps of cleanouts must be made up with graphite in oil alone.

Joints. — 55. Connections between lead and iron pipes must be made by heavy brass ferrules and soldering nipples with wiped and screwed, or calked, joints. 56. Joints of lead pipes, and all joints between lead pipes and brass fittings, to be wiped, soldered joints. 57. All wrought iron and brass joints to be screwed close up to the shoulder of fittings. In the case of N. P. and exposed pipes no threads to show beyond the shoulder of the fittings. 58. Joints between brass traps and brass pipes to be made screw joints. 59. All coupling joints on supply or flush pipes to be made with ground joint couplings. 60. Supply pipes to be put together with some ground joint brass unions, so that they may be easily taken apart for alterations or repairs. 61. All basin and other earthenware fixtures requiring it must be ground to fit the slabs, and must be set in dry white lead and shellac. 62. The joint between earthenware fixtures having backs and the backs must be true, and the backs set in dry white lead and shellac. 63. Brass traps and slop sink traps must be connected into 90-degree "Y" drainage fittings, so as to form a continuous waste and vent connection.

Brass Pipe. — 1. All pipes to be of annealed, seamless, drawn, tinned brass of iron pipe standard.

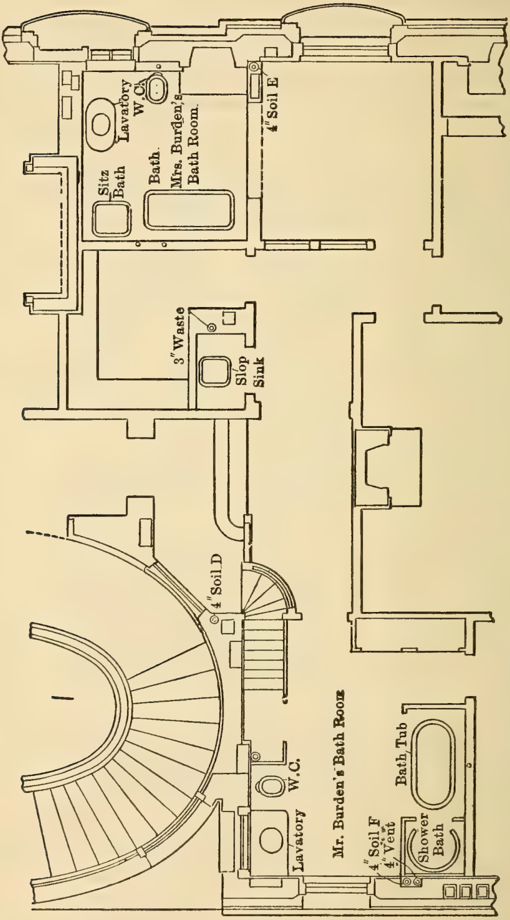


Fig. 172. Part of Floor Plan in the Burden Residence in New York City, showing Private Bath Rooms.

Exposed Fittings. — 2. To be hard, heavy beaded brass fittings, tinned and finished to correspond to the pipe.

Other Fittings. — 3. Where the pipes are not exposed about fixtures all fittings to be heavy beaded, malleable fittings, lined

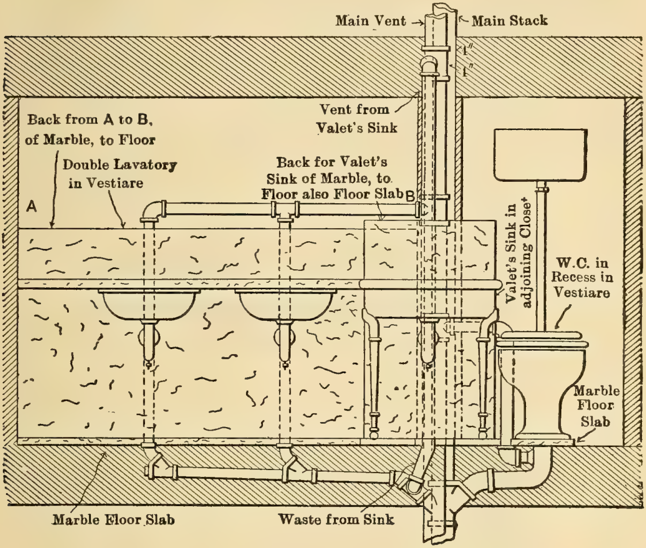


Fig. 173. Plumbing in Vestibule and Valet's Sink in Adjacent Closet of Burden Residence.

with tin and galvanized on the outside, made by Lamb & Richie, Cambridgeport, Mass.

Arrangement and Workmanship. — 4. Exposed work must be executed in a particularly neat and workmanlike manner. The pipe fittings, etc., must not be stained or marred by tool mark or otherwise. The threads must be so cut as not to show beyond the fittings, valves, etc. Suitable hangers to correspond to the work, and to be approved in advance, must be used. All ends of the pipe must be so cut that there shall be no burrs. All joints must be screwed joints of iron pipe standard. All pipes must be graded to drain at the lowest point, so that they may be completely and automatically emptied.

Valves and Cocks. — 5. All valves on supply lines to be finished brass gate, globe or angle valves with brass wheel handles,

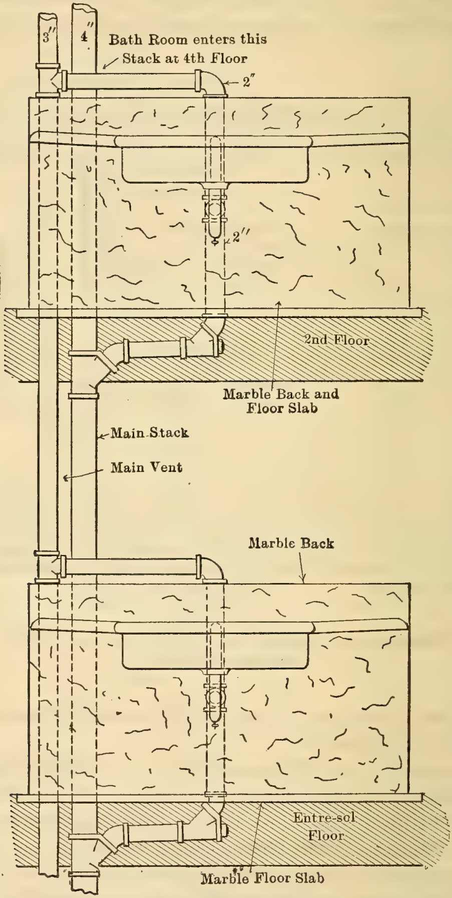


Fig. 174. Pantry Sinks, and Connections First and Second Floors, Burden Residence.

where exposed in rooms, and plated, polished or plain to correspond with pipe. No stop-cocks to be used. Gate valves to be Chapman Mfg. Co.'s and globe valves to be made by Jenkins

Bros. & Co., and so marked. Valves larger than $1\frac{1}{4}$ inch to be gate valves. 6. Cocks to be heaviest grade and finished or plated of patterns and materials specified. Compression cocks must have stuffing-boxes. All cocks and cistern connections, not specified, to have screwed-in connections, must have ground-in connection. 7. Place valves to control the main; the tank main; the pressure main; the filters; the pumps; the tanks; the hot water tank and boilers and heater; the risers and corresponding circulation pipes; the branches that are not taken from the risers; each fixture and cistern, and so as to provide the cross-connections and by-passes called for and otherwise as stated in detail. Provide $\frac{1}{4}$-inch drip valves near each valve on the basement ceiling. Provide a drip pipe emptying where directed.

Mains. — 8. Remove the present taps and insert a 2-inch Smith tap. Extend to inside the building by 2-inch pipe. Continue within the building by 2-inch pipe up to the suction tank. Provide from the 2-inch main a $1\frac{1}{2}$-inch branch for the pressure service, taken just inside of the front wall.

Pressure Service. — 9. Continue from the connection inside the front wall a $1\frac{1}{2}$-inch pipe to the pressure service filter and to the kitchen boiler, and $1\frac{1}{4}$-inch to the laundry boiler. 10. Form $1\frac{1}{2}$-inch hot and cold headers at the kitchen boiler. 11. Supply the fixtures below the second floor, except the laundry, from these headers. 12. Provide $\frac{3}{4}$-inch hot and cold risers to the third floor slop sink.

Water Meter. — 13. Provide and set, hung in pipe hangers, a 2-inch "Crown" water meter near the front wall.

Filters. — 14. Set in the pump room, where directed, two separate double cylinder filters complete, with tinned nickel plated brass pipe and fittings. The filters to be such as directed, and the cost of them is not to be included in the estimate for this contract. One filter to be on the pressure service main, the other on the down supply pipe from tanks.

Suction Tanks. — 15. Provide near the pumps a galvanized wrought iron suction tank, 3 feet in diameter and 6 feet high, supported vertically from the floor on a double ring stand of wrought iron. Provide flanged connections as follows:

One 2-inch for supply.

One 1-inch in head for relief.

One $1\frac{1}{2}$-inch in side near bottom for boiler, etc.

One 3-inch in side near bottom for pump suction.

One 1½-inch in bottom for emptying pipe. Finish the exterior of the suction tank in dull black to correspond with the filters; all exposed piping, valves, etc., about the suction tank to be nickel plated.

SUCTION MAIN. — 16. Provide from the suction tank to the pumps a 3-inch suction main. 17. Provide and set in the pump

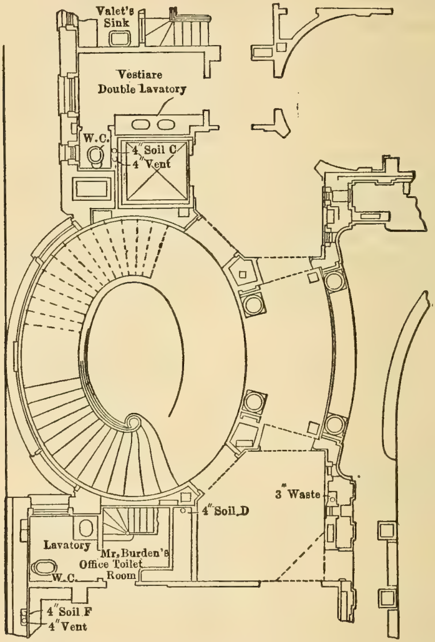


Fig. 175. Part of First Floor Plan in Burden Residence.

room, where directed, two (2) No. 3-A Quimby electrical house pumps, or two (2) Marburg electrical house pumps complete, with 3 horse-power motors, automatic motor starters and tinned copper ball tank floats, and electrical starting devices in each tank, including all necessary wiring. The latter to be in duplicate, each line of wiring connecting one tank to one pump. Set the starting apparatus so that one pump will have a lead of one foot in water level over the other. Provide a cross-connection of the

wiring system, so that the pumps can lead alternately. Provide switches for starting and cutting out each pump independently in the pump room. Provide a Zindars & Hunt automatic motor starter, polished, set in the engine room where directed. Provide for each pump an Edward's rheostat if necessary to secure regulation of speed. 18. The pump motor, motor starter and accessories to meet the electrical requirements of the building. 19. Provide brass pans, $1\frac{1}{2}$ inches deep and of necessary size, for the pumps, of ounce polished sheet brass, with edges wired over $\frac{2}{16}$-inch brass rod. 20. Provide $\frac{1}{2}$-inch brass drip pipes to the floor and continue to the floor drain by 1-inch galvanized wrought iron under the floor. Protect the outlets by a convex brass strainer. Provide between the pans and foundations a $1\frac{1}{2}$-inch sheet of hair felt, neatly covered by 24-ounce canvas painted two coats. 21. The pumps and motors, motor starters and starting devices must be furnished and installed complete with all accessories by one responsible person, who will be required to furnish a satisfactory guarantee for a term of five years.

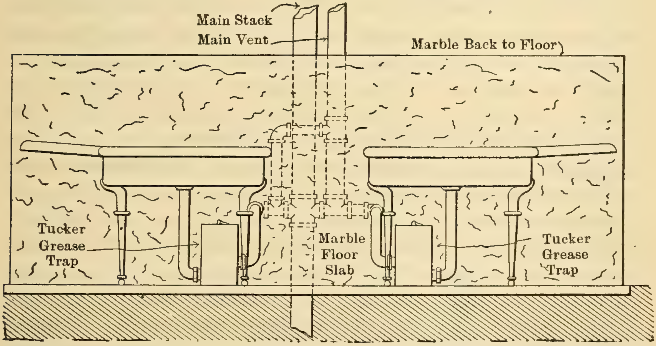


Fig. 176. Sectional View of the Kitchen Sinks in Basement of the Burden Residence.

(a) That each pump will deliver not less than 2000 gallons per hour under the actual conditions at the building.

(b) Guarantee the pumps, agreeing to replace them in whole or in part in case of failure or deterioration other than by reasonable wear or accident from external sources.

(c) Similarly guarantee the motors, motor starters, starting devices and accessories.

House Tanks. — 22. Provide and set in attic, where shown on plans, two (2) wrought iron house tanks, to have a capacity of 3000 gallons each below the water line. The tanks are to have a clear space on all sides of not less than 18 inches and are to be about 12 feet 6 inches long, 8 feet wide and 4 feet 6 inches deep. Support the tanks on steel beams, properly proportioned to distribute their weight, and carry it to the construction members suitable for the load. 23. The tank shell to be $\frac{3}{8}$ inch thick, suitably riveted and water-tight, and thoroughly braced with edge reinforced by 2-inch × 3-inch angle iron. The tanks to be covered by $\frac{1}{4}$-inch tight wrought iron covers, bolted to the tank rims with an air-tight joint. Provide two (2) scuttles, 30 inches square, with curbings of $\frac{1}{4}$-inch iron and covers of 1-inch clear white pine, tinned. Provide in side covers of $\frac{1}{4}$-inch wrought iron properly stiffened, and provided with lifting rings resting on $1\frac{1}{2}$-inch angle iron frames, set true and level, so as to secure a dust-proof joint. Provide in the top of each tank a 12-inch circular flanged opening, fitted with an air filter of wire mesh and wire gauze with a layer of cotton. Provide flanged connections as required for the use of the tanks. 24. Provide safes of $\frac{1}{4}$-inch wrought iron 6 inches deep and 6 inches wider than the tanks on all sides. 25. Set the tanks in the safes on 6-inch iron beams. 26. Set the safes at such a height that the safe waste pipes may discharge into the roof gutters. 27. Provide 4-inch galvanized iron overflows to the roof near the gutter, dip trapped to within 6 inches of the bottom of the tanks and provided with small crown vent pipes to prevent siphonage. 28. Provide 2-inch emptying pipes. 29. Provide 4-inch safe waste pipes into which the emptying pipes may be connected; extend to the roof near the gutter. 30. Provide brass flap valves on the overflows and safe waste pipes.

Pump Pipe. — 31. Extend from the pumps a 3-inch pump pipe with full sized branches to each tank and each pump. Enter the tanks near the ends.

Down Supply and Header. — 32. From two 3-inch cross connection between the tanks, provide a 2-inch down supply, continued to the tank pressure filter; at a point near the filter provide a header 3 inches in diameter of sufficient length for all necessary branches for which fittings are to be provided.

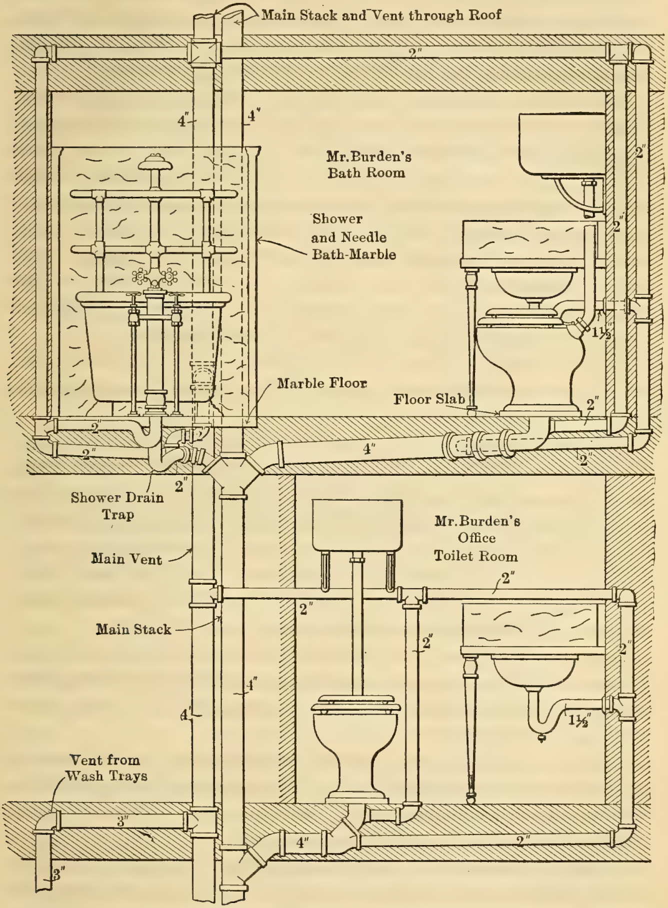


Fig. 177. Plumbing in Bath Room and Office Toilet Room of the Burden Residence.

Hot Water Heater. — 33. Provide and set in the boiler room a No. 021 round "Richmond" hot water heater. The hot water pipes on top must not be bushed but be extended full size, 1 foot, and be reduced with a long reducer. 34. Provide $2\frac{1}{2}$-inch flow and return pipes for the boiler with flanged unions.

Hot Water Boiler. — 35. Provide and set a double riveted galvanized wrought iron boiler of 300 gallons capacity, approximately 3 feet in diameter and 6 feet 3 inches long over all, with dished heads (the body to be $\frac{5}{16}$ inch and the heads $\frac{3}{8}$ inch thick), hung from the floor beams or supported from the floor in a $1\frac{1}{2}$-inch galvanized wrought iron pipe frame. The boiler to be tested under a hydraulic head of 2000 pounds per square inch, and so guaranteed by the maker, or actually tested on the premises; provide a flanged handhole for inspection. Make all necessary flanged connections as per detail diagram.

Hot Water Header. — 36. Provide a 3-inch hot water header near the cold water header in the pump room, similar to the cold water header.

Kitchen Boiler. — 37. Provide and set in the kitchen, over the hood of the range, an 80-gallon "Browns" 20-inch extra heavy copper boiler, as made by the Randolph-Clowes Company, with connections as per detail diagram, all to have female threads, hung in copper bands from the floor beams or otherwise supported in a manner to be previously approved. 38. Flow and return pipes $1\frac{1}{4}$ inch and $1\frac{1}{2}$ inch of polished brass with polished brass unions, and full sized connections with the water back.

Laundry Boiler. — 39. Provide and set in the laundry an 80-gallon boiler, otherwise the same as kitchen boiler complete, as specified above. 40. Flow and return pipes $1\frac{1}{2}$ inches, otherwise as specified above.

Air Chambers. — 49. Provide air chambers at all fixtures, 18 inches long where possible, and where exposed they must be connected with continuous "T" and quarter bend in one piece and finished at the top with acorn caps.

Other Branches. — 50. Provide three (3) 1-inch branches, where directed, for sill cock, with valves in side and large size wheel handles hose nozzle "Cooper" sill cocks outside. Arrange these to drain through valves. Provide a similar hose cock in the engine room taken from the fire main.

Covered Supply Pipes and Branches. — 51. Horizontal supply pipes and branches are to be run in boxes of 20-ounce

copper, pitched continuously to outlets, and provided with $1\frac{1}{4}$-inch galvanized wrought iron safe waste pipes to the cellar ceiling where described in detail below. 52. These boxes must be suitably supported on plank bottom strips, and have water-tight soldered joints and wiped joints, where pipes pass through them, and brass pipe soldered nipples at the safe waste pipes and have covers soldered on. They must be 4 inches deep where possible, and of widths necessary to keep all pipes at least 4 inches apart and 1 inch from the sides, with the circulation pipe, where there is one, in the center. All pipes in these boxes must be secured in place by loose fitting copper straps soldered to the boxes. 53. Location of boxes: 1. At the branches for fixtures in both bath

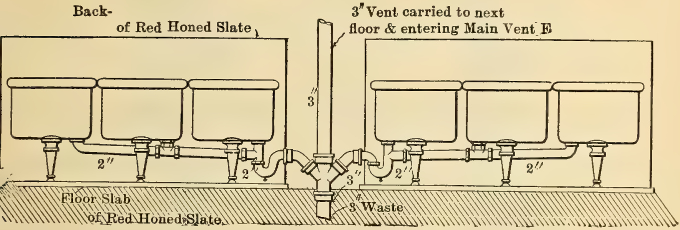


Fig. 178. Porcelain Laundry Trays in Basement of the Burden Residence.

rooms on the entresol. 2. At the branches for fixtures in both bath rooms on the third floor. 3. At the branches for fixtures in the two front bath rooms on the fourth floor.

Material and Workmanship. — 56. Workmanship shall be under the same specifications as for water supply. 57. The pipes shall be of brass, as specified for water pipes. 58. Fittings shall be malleable galvanized drainage fittings, and if any sockets are required they shall be of malleable iron, similar to drainage fittings. 59. The valves and racks to be nickel plated and polished brass. 60. All hose, valves, racks and reels to be of the best grade manufactured by estate of John C. N. Guilbert. 61. In sub-basement provide two racks, one (1) in the boiler room, where shown, and one (1) at the foot of the servants' elevator. On the basement and first to fifth floors provide one (1) rack, where shown, at the servants' elevator. 62. The racks and reels to be swinging hose racks, as shown on page 16 of John C. N.

Guilbert's catalogue, of the size to carry and supplied with 60 feet of unlined linen hose of the best grade.

Figs. 179 to 184 show the plumbing work in the W. B. Hibbs & Co. Office building, Washington, D. C.

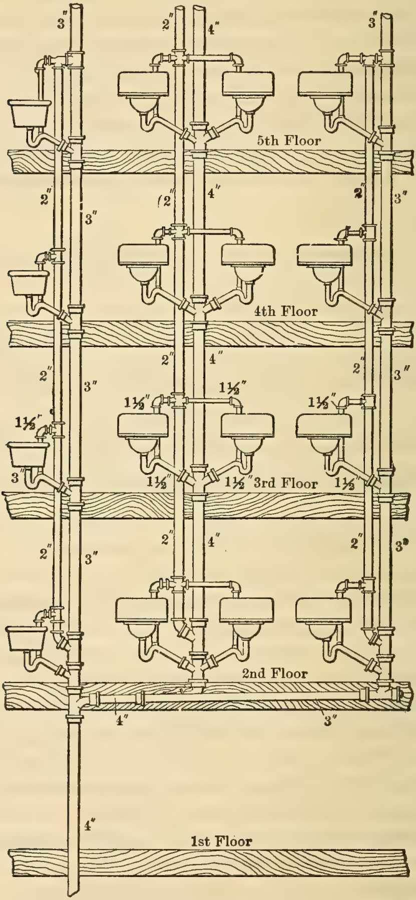


Fig. 179. Connections from the First to the Fifth Floor of the Hibbs' Building.

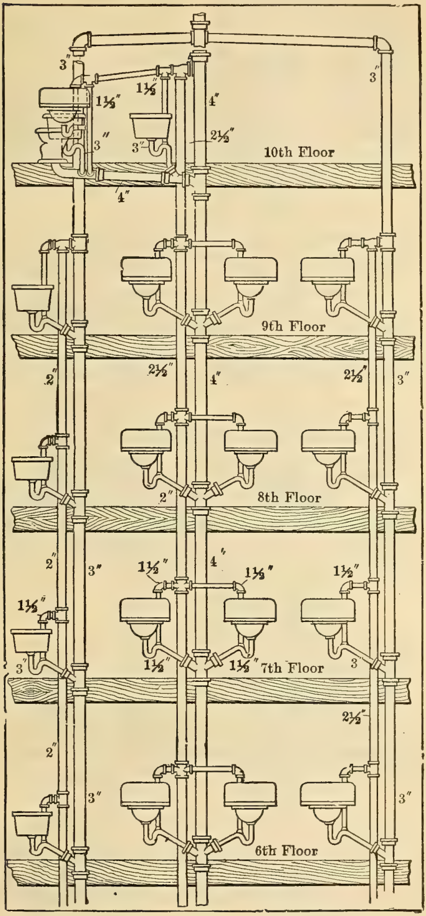


Fig. 180. Connections from the Sixth to the Tenth Floor of Hibbs' Building.

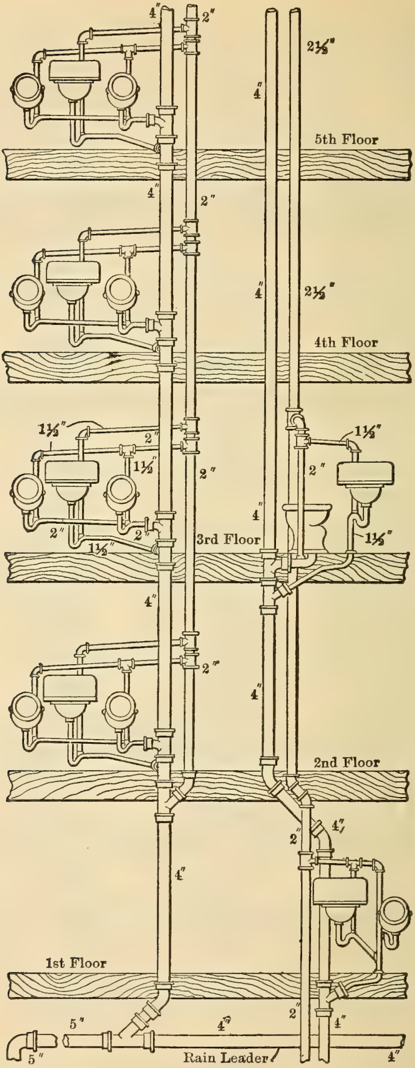


Fig. 181. Toilet Fixtures from the First to the Fifth Floor in the Hibbs' Building.

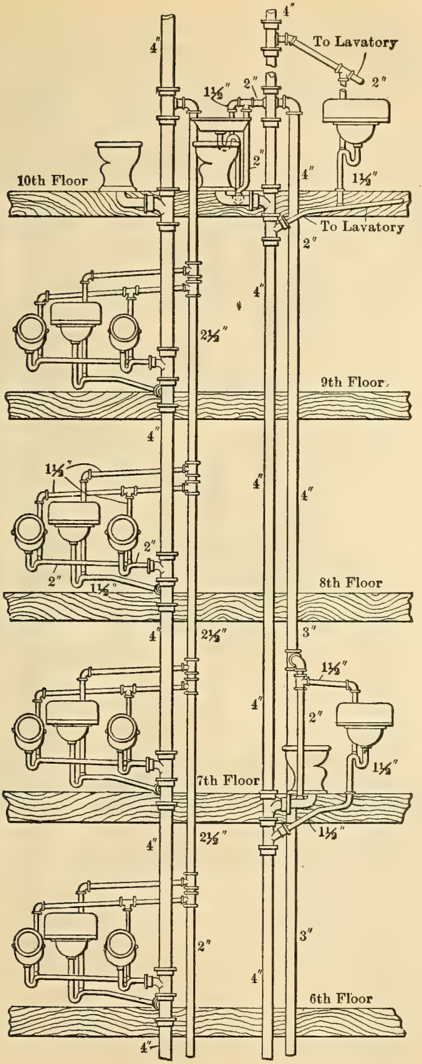


Fig. 182. Line of Fixtures in the Hibbs' Building.

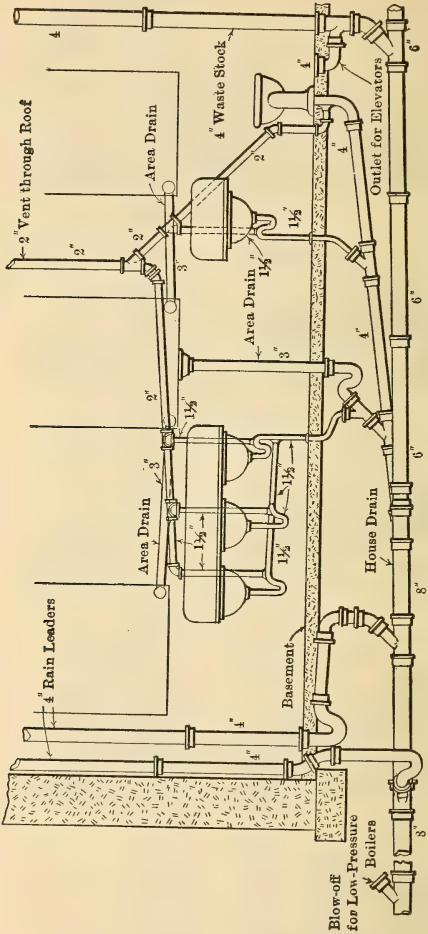


Fig. 183. Basement Plumbing in the Hibbs' Building, Washington, D. C.

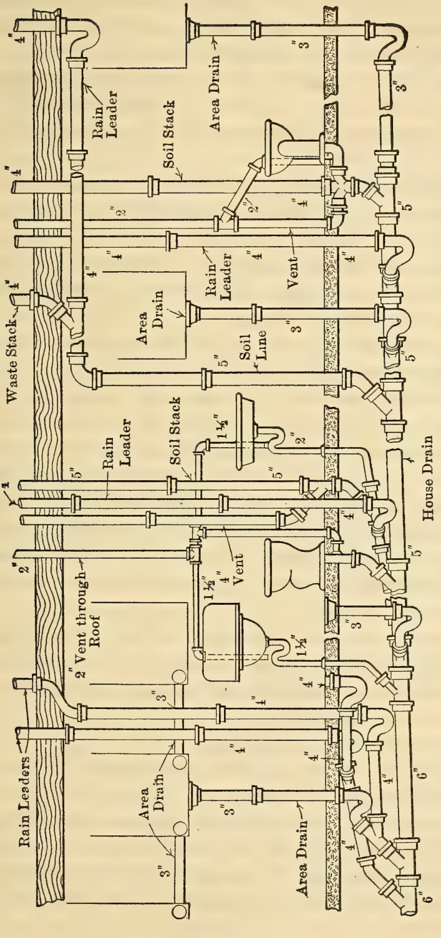


Fig. 184. Another View of the Plumbing in the Basement of the Hibbs' Building.

Modern Plumbing Specifications.

As an example of modern specifications the following, which were used on work done under the Supervising Architect of the Treasury Department, Washington, D. C., are given:

General Description. — This section of the specification includes the installation complete of the plumbing, drainage water and gas supply systems and the marble finish of toilet rooms.

The sanitary and drainage systems will be combined with two 8-inch connections to 21 diameter combination sewer in Lincoln Avenue.

Soil, waste and drain pipes below basement floor to be cast iron and all above to be galvanized wrought iron and all run as indicated and noted on drawings.

Ventilation of sanitary system will be by end or circuit vents and individual trap vents will not be required.

The drain pipe for boiler blow-off tank to be installed under another contract, is to be run separately and be connected to one of the main connections beyond building wall as shown.

The drainage from roof will be by means of down spouts discharging into sanitary system as indicated on the drawings.

The city water supply is a Holly System and the piping in the building will be arranged to utilize high pressure on the fire and street washer lines and low pressure through a reducing valve on the sanitary system.

Kind and Quality of Material. — The required appliances, materials, fixtures, etc., furnished must in each case be in strict accordance with the specification and of the best quality and grade found in the market.

Especial attention of bidders is called to the fact that they must fill out the proposal sheet and supply the information required thereby, as to name and address of manufacturers, catalogue number or trade name of the materials and appliances they propose to supply, and especial attention is called to the fact that where required by proposal sheet, the names of three different manufacturers of the material or appliances must be given.

In the event that the successful bidder does not submit the name of manufacturer, etc., of material and fixtures, as required by the proposal sheet, or in the event material or appliances

named by him are not in strict accordance with the specification requirements in regard thereto, or are not deemed to be of the best quality and grade found in the market, the Supervising Architect reserves the right to select the material, etc., which selection will be final and binding on the contractor, and the materials, etc., selected must be installed for the contract price.

Especial attention of bidders is called to the fact that it is the intention of this office to install, as far as possible, a line of plumbing fixtures, not only in accordance with the specification but which are also the complete product of one manufacturer, and preference will be given in the consideration of proposals, other things being equal, to the proposal which proffers fixtures in accordance with the intention above expressed. By complete plumbing fixtures it is to be understood that not only fixture proper is meant but also all valves, traps, fittings, etc.

Patents. — The department will not recognize demands brought on account of infringement of patents, but will hold the contractor and his bondsmen strictly responsible for any delay or any cost resulting from his failure to fully protect the government against patent rights.

Approval of Material, etc. — The approval by the department of any appliance or material named on the proposal sheet is to be understood as an approval of same only upon its conformity with the specification requirements in regard thereto, and not as an absolute acceptance of the article without respect to the requirements of the specification.

Samples. — The contractor must furnish for the approval of the Supervising Architect, all the samples hereinafter called for and must also, if required by the Supervising Architect, furnish samples of any or all of the material, fixtures, etc., he proposes to use. Contractor must pay all express charges on samples. Especial attention is called to the fact that no material or appliances of which samples are required to be submitted for approval will be permitted to be placed in the building until such approval has been given by the Supervising Architect.

The samples approved of may be used in the work after serving their purpose as samples. All samples must be accompanied by a letter of transmittal from the contractor and each sample must be marked with name of contractor and the name of the building in which it is proposed to be used. Rejected samples will be

returned to the contractor by express at his expense unless he advises the office specifically to the contrary when submitting samples.

In the event the contractor delays the submission of samples so that there does not appear to remain sufficient time for action on samples and for the execution of the work within the contract time, the department reserves the right to return submitted samples, without approval, at the expense of the contractor, and to abrogate the contract or have the work performed at the expense of the contractor.

Tests and Inspections. — Upon entire completion of the plumbing, gas piping, and electric wiring and conduit system and upon completion of heating apparatus, except applications of non-conducting coverings, the contractor shall give written notice to the Supervising Architect through the Superintendent, of his readiness for inspection and test.

Should the inspection or test not be begun, through no fault of the contractor within ten (10) days of the receipt of notice by the Supervising Architect, allowance will be made as herein-before provided.

Should the inspection and tests be delayed upon the arrival of the inspector or require repetition for any reason for which the contractor is responsible, the cost of delayed or subsequent inspection and test, including the salary, traveling and other expenses of the Department Agent, shall be at the expense of the contractor, and will be deducted from any money due the contractor upon the contract.

All questions as to the satisfactory completion of the work, and defects necessary to be remedied, are to be determined by the Supervising Architect or his authorized representative.

In the event the contractor does not remedy any defects or make such changes as may be demanded by the Supervising Architect, to satisfactorily complete the contract, within a reasonable length of time, the right is reserved to have defects remedied or changes made and to charge the cost of same against the account of the contractor.

Permits, etc. — The contractor must obtain all permits and pay all fees and charges and comply with the rules and regulations of the city, and the gas and water companies in regard to connecting with sewers, gas and water mains, etc.

He must comply with all the regulations in regard to street

excavations and repairs. The local authorities and companies are to have jurisdiction over only such work as is outside of the lot line of the building.

Guarantee. — Contractor must guarantee each and every part of the work specified under this section, and will be required to remedy at his expense all defects which may develop by reason of the use by the contractor of any inferior or defective materials or workmanship. It must be understood that the acceptance of the work will not relieve the contractor for having installed defective material and work not apparent at time of final inspection.

Soil, Waste and Drain Piping. — Runs of soil, waste and drain pipes must be of the sizes and run as indicated and noted on the drawings; connections to fixtures to be of the following sizes for each fixture: water closets, 4 inches diameter; slop sinks, 3 inches diameter; urinals, shower baths and galvanized iron sink and batteries of three lavatory basins, 2 inches diameter; batteries of two lavatory basins, $1\frac{1}{2}$ inches diameter; single basin lavatories, $1\frac{1}{4}$ inches diameter. No connection below basement floor to be less than 2 inches diameter.

Soil, waste and drain pipes below basement floor must be run at grades noted on the drawings. Soil and waste pipes above basement floor are to be given a grade of $\frac{1}{4}$ inch per foot where possible.

Vent Piping. — The soil and waste stacks indicated on drawings must be extended full size as a vent pipe 3 feet above the roof line.

Where so indicated or noted on the drawings, two or more vent pipes are to be collected and extended above the roof as a single pipe.

If an end of circuit vent pipe from a fixture or line of fixtures on an upper floor is to be connected to a vent pipe from fixture or fixtures located on a lower floor, the vent pipe from fixture or fixtures on upper floor must be run up about 4 feet above floor before connecting with vent pipe from fixture or fixtures on lower floor, so as to prevent any vent pipe acting as a waste pipe.

Horizontal runs of vent pipes must where possible be given an up grade toward the main vertical vent line.

Vent pipes extending above the roof are to be direct extensions of soil or waste pipes wherever practicable unless otherwise shown on the drawings.

Openings through the roof for vent pipes must be flashed with 8 pound sheet lead or drawn lead pipe of equal weight; the flashing to be flanged and soldered water-tight at roof and the lead to extend around the vent pipes for a distance of 10 inches above the roof line. At top line of the lead flashing a drilled and threaded standard cast iron cap one size larger than vent pipe is to be screwed to each vent pipe to form counterflashing or rain guard.

Down Spouts. — Down spouts are to be connected to roof gutters as hereinafter specified.

Water Supply System. — The water main in Riverside Avenue is to be tapped at point where directed by the superintendent, and approved by the water company, and a 2½-inch diameter water supply pipe brought into the building.

A gate valve with tee handle with cast iron extension stop cock box and cover, to be placed on the water supply pipe, near the curb line, and the connections with the street main and the material of pipe from street to building to be made in accordance with the regulations of the City Water Works.

On the water main just inside of the building wall a double seat gate valve must be provided.

Just beyond main gate valve, full sized valved outlets must be left in horizontal pipe for water meter, and a locked meter cock with two keys must be provided on water main between outlets. The furnishing and setting of meter is not included in this contract.

A 1-inch diameter drain connection with gate valve and hose nipple is to be provided on water main pipe near meter connection so that a hose may be attached and entire system be drained.

After leaving meter connections the main water supply pipes are to be run up to basement ceiling and along same, with branches of the sizes noted, for supplying hot water boiler and all the plumbing fixtures, etc., indicated on the drawings.

An approved positive acting pressure reducing valve is to be placed on main water pipe in basement that supplies the plumbing fixtures where indicated; gate valves to be placed on each side of reducing valve and a valved by-pass connection provided at reducing valve.

An approved 3½-inch dial Japanned iron case, pressure gauge, graduated to 200 pounds is to be provided on water main each side of the pressure reducing valve.

Cold water supply pipes to toilet rooms having three or less fixtures to be not less than 1¼-inches diameter; where more than three and not exceeding eight fixtures are located, supply pipe to be not less than 1½-inch diameter; where more than eight fixtures are located, supply pipe to be not less than 2 inches diameter; in event larger supply pipes are required to properly operate the number of flushing valves, contractor must furnish same without additional cost to the government.

Hot water supply pipes to toilet rooms having two or more fixtures to be ¾-inch diameter except large basement toilet room which must be 1-inch, hot water supply to single basins and shower bath to be ½-inch diameter and to sinks to be ¾-inch diameter.

The branch water supply pipes to the different fixtures are not shown on the drawings. The contractor must run the same in the most direct manner. Especial attention is called to the fact that no water pipe in toilet rooms will be permitted to be buried below floors or behind marble work or plaster in walls, and that all pipes are to be run exposed and so as not to interfere with any window or other opening. Risers supplying toilet rooms on upper floors to be run as shown on drawings in chases or up in vent shafts.

Water supply pipes to be not less than ½-inch diameter for the lavatories and shower baths, ¾-inch diameter for sinks, 1-inch diameter for urinals, 1¼-inch diameter for water closets.

A 1½-inch plugged "T" for boiler supply to be provided on water main where indicated on basement plan.

Hot water pipes of the given sizes are to be run from the hot water boiler to each lavatory basin, shower bath fixtures, slop sink and galvanized iron sink in the building.

Each hot water riser in the building is to have a circulating pipe taken from hot water riser about on a line with the floor, just below connection of top fixture supplied from that riser. The circulating pipes are to be parallel, the hot water risers and the main supply in basement, and the circulating main is to return into bottom of hot water boiler at which point a check valve is to be installed. Circulating pipe risers to be ½-inch diameter pipe and mains one size smaller than hot water mains.

The water supply pipes at points indicated on basement plan, and on main supply to each toilet room and on supply to each flushing valve to be fitted with heavy pattern double seat gate

valve, circulating pipes to have valves corresponding with hot water valves; stop cocks will not be permitted.

Valves to be placed in accessible position.

CAST IRON PIPE. — All soil, waste, vent and drain piping in the building below the basement floor line, and the connections to city sewer in Lincoln Avenue to be best quality "extra heavy" cast iron hub and spigot pipe, of the following average weights per lineal foot: —

2-inch diameter pipe to weigh $5\frac{1}{2}$ pounds.
3-inch diameter pipe to weigh $9\frac{1}{2}$ pounds.
4-inch diameter pipe to weigh 13 pounds.
5-inch diameter pipe to weigh 17 pounds.
6-inch diameter pipe to weigh 20 pounds.
8-inch diameter pipe to weigh $33\frac{1}{2}$ pounds.

All fittings for cast iron pipe to be of corresponding quality and weight.

Cast iron pipe must be straight, cylindrical in bore, of even thickness, spigot end provided with bead and hub end must be perfect so that satisfactory joints of even thickness can be made.

All connections and turns, where possible, must be made where possible with "Y" fittings and $\frac{1}{8}$ or $\frac{1}{16}$ bends. Sanitary bend and tees may be used for connections of branch lines to fixtures.

WROUGHT IRON PIPE. — All soil, vent and down pipe, above basement floor, and all waste and water pipe (unless otherwise specified) must be best quality galvanized wrought iron screw jointed pipe of standard weight and thickness.

Fittings for wrought iron or steel soil, waste and drain piping must be heavy pattern, galvanized cast iron, recessed and beaded, screw jointed, drainage fittings; where space and other conditions permit, long turn bends must be used for changes in direction of runs and regular pattern Y branches or long turn T pattern Y branches must be used for all branch connections.

The fittings for wrought iron or steel vent and water piping must be standard, beaded galvanized, cast iron or galvanized malleable iron, screw jointed fittings

BRASS PIPE. — All lavatory waste pipes exposed between lavatory slabs and floor line and all water supply pipe in all toilet rooms below top line of marble wainscot in said rooms is to be brass pipe. For lavatories located in office rooms the waste pipes and water pipes thereto exposed between lavatory

slab and floor line are to be brass pipe. *Especial attention* is directed to the fact that all the brass water pipe and all brass *waste* pipe on *sewer* side of traps must be *wrought iron* pipe size and thickness. All brass pipe to be annealed, seamless drawn tubing, nickel plated and polished.

Jointing and Connections. — All joints between cast iron pipe and between wrought iron and cast iron pipe are to be made with picked oakum gasket and pig lead. Joint to be run full at one pouring, and calked solid, flush with hub. End of wrought iron pipe when jointed to cast iron pipe to have a ring or part of a coupling screwed on to form a spigot.

Screwed joints to be made with red lead and boiled linseed oil or other approved compound. Flange unions or standard couplings are to be used on all wrought iron soil pipe, interior down spouts and interior roof drainage piping and on all wrought iron waste and vent pipes larger than 2-inch diameter. On all wrought iron or steel piping 2-inch diameter and smaller, especial attention is called to the fact that no malleable iron unions or long screws or other packed joints will be permitted; on all such pipe either right and left screw couplings or preferably all brass ground joint unions must be used.

Unions on waste pipes on fixture side of trap may be slip or flange joints with soft rubber or leather gaskets.

All unions on brass water pipe and *all* unions on *sewer* side of traps must be all brass ground joint unions, nickel plated, having full area of the pipe on which they are used and free from all obstructions.

The outlets from roof gutters shall be connected to the interior standard galvanized wrought iron or steel down pipes with lead pipes of same diameter, weighing not less than 8 pounds per foot. Lead pipes to be enlarged to twice the area of pipe at inlet at gutter and be flange under gutter lining and soldered thereto.

The lower end of lead pipe to be wiped (where space permits) to brass coupling (recessed for lead pipe) which is to be screwed to the iron down spout.

Hangers and Supports. — Horizontal runs of iron pipe must be hung with approved wrought iron or malleable iron pipe hangers, spaced not over 10 feet apart, vertical pipes to have heavy wrought iron clamps or collars for supports spaced not less than one to each floor. All hangers and collars must be of a size proportionate to the weight of the pipe supported.

Chain or wire hangers will not be permitted.

Pipe Sleeves. — Cast iron or standard galvanized wrought iron pipe sleeves as hereinbefore specified must be provided for all pipes passing through brick walls except pipes for wall hydrants; pipe sleeves are to be installed through the foundations of steps for gas and water supply mains, as indicated on basement plan. Iron pipe conduits for electric wires must be run from all outside light outlets, as shown, to inside of basement wall, at ceiling, where junction boxes must be provided.

Floor and Ceiling Plates. — Where pipes, not hereinafter specified to be covered, pass through floors, ceilings and walls of finished rooms, they must be fitted with floor and ceiling plates. Plates on nickel plated pipe must be heavy cast brass nickel plated, and on iron pipes to be cast iron bronzed, same as pipes; wall and ceiling plates to be securely fastened in place.

Bronzing. — After all iron or steel piping has been tested and approved, all such pipe exposed in toilet rooms and in other finished rooms not hereinafter specified to be covered, must be thoroughly cleaned and primed and given one coat of aluminum bronze or cleaned and given one coat of shellac and two coats lead and oil paint.

Cleanouts. — The cast iron cleanout fittings on runs of pipe in brick manholes below basement floor are to be extra heavy pattern, the full size of pipes in which installed, with gasket and cover plates complete. Covers to be secured with wing nuts or bolts.

A "T" fitting with brass screw jointed cleanout plug is to be placed near the base of each vertical soil, down, vent and waste pipe in the basement. The cleanout plugs to be the same size of pipe in which they are placed. Extension pieces to be placed in tees to bring plugs flush with walls where pipes run in chases in plastered rooms. Where cleanouts occur back of marble, same is to be cut out neatly for access to plug and plug to be finished and nickel plated.

Cleanout Manholes. — The manholes for cleanouts in basement are to be of the size and constructed as shown by detail on drawing. The walls to be of brick, laid in cement mortar and plastered on the inside with same $\frac{3}{4}$-inch thick, built on a 6-inch thick bed of concrete. Walls of cleanouts may be of concrete in lieu of brick specified, if desired.

Frames and covers constructed of $\frac{1}{2}$-inch thick cast iron with

iron lifting handles and diagonal channeled top surfaces to be provided and set for cleanout manholes; top of frames and cover to be set flush with finished floor line. Where cleanout manholes occur in rooms with wood floors, the cast iron cover must be set flush with finished wood floor.

Running Traps. — A running trap with brass screw jointed recessed or countersunk cleanout plug set flush with basement floor line must be placed on connections which are to be extended under another contract to cesspools in mail lift and ash lift pits, where indicated on basement plan. Cast iron P traps with recessed cleanout screw-plugs flush with basement floor are to be placed at the base of all down spouts from the low roof over P. O. work room.

Valves. — Valves, except the compression stops specified under "Fixtures," must be heavy pattern double seat brass gate valves of first class and approved construction. Valves on brass pipe to be finished all over and nickel plated. Valves on flush meter connections to be of the lock shield pattern with detachable keys.

Each valve must have the name or trade marks of the manufacturer, either cast or stamped on same.

Pipe Covering, etc. — After the system of cold and hot water pipes is in place, connected, tested and approved, this contractor must cover all cold and hot water pipes in the building (except the brass, nickel plated piping with first class approved non-conducting sectional felt covering, canvas jacketed, put on in a workmanlike manner using solid brass bands of not less than No. 30 B and S gauge or less than $\frac{3}{4}$-inch wide, and moulded, sectional removable covering for valves and fittings. Coverings to be not less than $\frac{5}{8}$-inch thick, for cold water piping to be lined with tar paper and for hot water piping to be lined with asbestos paper.

Duplicate samples of coverings and brass bands proposed to be used must be sent to the supervising architect for approval before the coverings are applied. After the coverings have been applied and accepted they are to be painted with three coats of best quality lead and oil paint, finishing tint to be approved.

The brass bands to be removed while covering is being painted and replaced after paint is dry.

Bidders must state on the proposal sheet the amount included in total bid for covering hot and cold water pipes.

A neat brass nickel plated escutcheon, held in place by set screw or spring clip is to be used at point where galvanized iron water pipe ends and brass pipe begins to protect end of covering on galvanized iron pipe.

SCHEDULE OF FIXTURES.

Basement.

Water closets	13
Urinals	5
Shower baths	3
Rectangular lavatories	4
Corner lavatories	2
Galvanized iron sink	1
Slop sinks	2
Water heater	1
Fire hose reels	2
Wall hydrants	6

First Story.

Water closet	1
Rectangular lavatories	2
Corner lavatories	3
Slop sinks	2
Fire hose reels	3

Second Story.

Water closets	11
Urinals	2
Rectangular lavatories	6
Corner lavatories	6
Slop sink	1
Fire hose reels	3
Shower bath	1

Mezzanine Floor.

Water closets	2
Rectangular lavatory	1
Slop sink	1

Third Floor.

Water closets	11
Urinals	2
Rectangular lavatories	7
Corner lavatories	5
Slop sink	1
Fire hose reels	2

Water Closets. — Furnish and set in place where indicated on plans, large size, extra heavy pattern flushing rim, siphon jet water closets, with trap, moulded in earthenware, substantial pedestal base, floor flange, etc. Closets to be "Class A" and free from fire cracks or other defects, and are to be straight and true in shape.

Each closet bowl must weight not less than 75 pounds.

Closets to be white vitreous earthenware, unwarped, with flanges, tops, etc., in true planes, each to have pottery's vitreous stamp under the glaze, of first class construction, free from defects as to material, workmanship and finish.

Water closet connections in basement toilet room to be made with 4-inch diameter drawn lead piping weighing 8 pounds to

the foot, lower end to have a brass ferrule at least 1 inch longer than depth of cast iron hub into which it is to be calked; the lead to extend not less than 1 inch inside of the ferrule and connected to same with a wiped joint. Upper end of lead connection to be soldered to a heavy cast brass floor flange.

The water closet connections above basement are to be made with heavy pattern screw jointed cast brass floor flanges and 4-inch diameter wrought iron nipples of proper length screwed to wrought iron soil pipe fittings; cast brass floor flanges with male thread may be used in lieu of above.

Closets to be bolted to the brass floor flanges with brass bolts; exposed heads of nuts of bolts to be nickel plated.

Joints between closets and floor flanges to be made absolutely water- and gas-tight with special moulded gaskets, properly saturated to prevent rotting and drying. Rubber gaskets will not be permitted for this connection.

Approved screw joint connections may be made between water closets and soil pipes in lieu of the connections specified above if so desired by the contractor.

An approved rubber buffer is to be provided at each water closet for seat to strike against when raised.

Seats for closets to be well seasoned white oak strongly framed and highly polished, not less than $1\frac{1}{4}$ inches finished thickness. Seats to be attached directly to the closet bowls with heavy pattern brass nickel plated hinges.

A heavy pattern brass nickel plated double coat hook and a brass nickel plated toilet paper holder for roll paper must be furnished and securely bolted to the marble work near each water closet as directed by the superintendent of construction; paper holders must be constructed so that the roll cannot be removed until all the paper is unrolled.

Urinals. — The urinals to be large size, siphon jet lipped patte, flushing rim with trap moulded in earthenware, designed to hold a body of water. Urinals to be "Class A" white vitreous earthenware, unwarped, with backs, etc., in true planes. Each to have pottery's vitreous stamp under glaze, and to be of first class construction, free from defects as to material, workmanship and finish.

All exposed metal fittings in connection with urinals to be finished brass nickel plated.

Flushing Valves. — Each water closet and urinal is to be

provided with an approved brass heavily nickel plated flushing valve, with heavy operating lever; handles of flushing valves to be finished brass heavily nickel plated and must be permanently fastened to the operating levers. Valves operated by push button device will be acceptable in lieu of valves operated by lever.

Each valve must have a regulating device to adjust the amount of flush water and give a proper after fill; the flushing valves must have no springs except in connection with push button.

A finished brass heavily nickel plated ground joint union must be provided on connection between each cut off valve and flushing valve.

Each bidder must understand that he will be required to guarantee the flushing valves he proposes to use for a period of one year, if his proposal is accepted; and to guarantee the proper operation of valves during said time the contractor will be required to make all necessary repairs and keep in proper working order all said valves at his own expense.

If at any time before the expiration of said one year the government decides that the valves supplied are unsatisfactory, they must be removed by this contractor, who must furnish and place on each fixture specified a new flush valve; the department reserving the right to select the make of flush valve to be substituted.

Lavatories. — Lavatories are to be approved pattern, "Class A," heavy white vitreous earthenware. Rectangular lavatories except those in office rooms to be without backs, not less than 24 inches x 20 inches with bowls not less than 12 inches x 16 inches. Corner lavatories to be not less than 23 inches x 23 inches, with bowls not less than 12 inches x 16 inches, and are to have an integral back not less than 6 inches high. Rectangular lavatories in office rooms to have integral back 6 inches high. Lavatories must be properly supported on heavy cast brass nickel plated brackets of simple design. Brackets to be secured to wall with through bolts or heavy expansion bolts with nickel plated heads.

The rectangular lavatories in toilet rooms are to be set off from the marble wainscot not less than 2 inches, and when two or more lavatories are set side by side there must be a space of not less than 2 inches between fixtures.

A vitreous earthenware one piece two basin lavatory of approved

design, not less than 22 inches x 48 inches, having two bowls moulded in single fixture, will be acceptable, in lieu of two single bowl fixtures hereinbefore specified, where two bowls are required side by side.

Each individual lavatory bowl to have an approved $1\frac{1}{4}$-inch cast brass nickel plated non-siphoning trap without ball float or other movable parts and without vent connections. Trap to have either male or female $1\frac{1}{4}$-inch iron pipe thread connection for waste pipe. If brass coupling is used to form female connection it must be screwed to the body of trap, not soldered. The connection between tail piece of lavatory waste coupling and trap may be made with rubber expanding ring or leather washer. The waste plug coupling of lavatory must be cast brass, nickel plated where exposed, neatly fitted to recess of bowl, with strainer bars and patent over-flow arrangement. The coupling nuts used to assemble trap and waste pipe connections to be cast brass with chased threads. No stamped or rolled nuts will be accepted. If it is necessary to provide a union in waste pipe on the sewer side of trap, same to consist of a metal to metal union, without contracted area or obstruction, exposed parts of unions to be nickel plated and polished. The nipples and pipe connections between trap and concealed piping to be standard, annealed, drawn brass tubing, full iron pipe size with screw threaded joints throughout.

Approved plain heavy pattern "Fuller" hot and cold water faucets with ground joint union in bodies, so that same can be readily taken apart for repairs, must be provided for each lavatory basin; the hot and cold water supply pipes to each faucet must be provided with a brass nickel plated, milled wheel compression stop with stuffing-box. The connection between faucet and supply pipe to consist of a ground joint swivel connection. The coupling nuts used to be of substantial design to prevent stretching. The swivel or tail piece to be of heavy brass with ground cone and iron pipe thread with $\frac{1}{2}$-inch reducing socket screwed to same and soldered; the whole to be polished and nickel plated. The mechanism of faucet to be perfect in every respect. The eccentric and stem to be perfectly fitted and the gum ball to be secured to stem with cone shaped expanding washer and brass hexagon nut. Packing nut and gland to be so designed that a water-tight, easy moving joint will be obtained. Weight of each faucet to be not less than two (2) pounds.

Each basin must also have a soap holder and chain stay set opposite center of basin with No. 3 safety chain and rubber plug.

A towel rack must be provided near each lavatory; racks for single basin lavatories to be 24 inches long, for more than one basin to be the combined length of lavatories.

Towel racks to be constructed of $\frac{3}{4}$-inch diameter brass tubing with ornamental caps at ends and supported about 3 inches from wall with heavy pattern brass brackets securely bolted to wall where directed by superintendent.

All metal fittings and connections of lavatories must be finished brass, heavily nickel plated.

Slop Sinks. — The slop sinks in toilet and janitor rooms to be not less than 18 inches x 22 inches x 12 inches deep of best grade heavy plain white earthenware, "Class A," glazed inside and outside, fitted with finished brass nickel plated flushing rims.

Sinks to have brass strainer on the waste and to be provided with a 3-inch cast brass nickel plated non-siphoning trap standard without vent.

Connections to waste pipes to be made similar to connections specified for water closets.

Hot and cold water connections to be provided for each sink, fitted with approved combination faucets, and with a direct valved water supply to flushing rims, connections to be secured to marble wainscot with brass clamps and expansion bolts. All fittings to be finished brass nickel plated.

Hot and cold water connections to be provided with brass nickel plated milled wheel compression stops with stuffing-boxes.

Galvanized Iron Sink. — The engineer's sink in basement to be 36 inches x 18 inches x 6 inches deep, galvanized iron, provided with galvanized iron back with air chambers for water connections and supported on two galvanized iron brackets secured to wall with expansion bolts, located where shown on drawing. Sink to have a brass strainer on waste and a 2-inch diameter rough brass non-siphoning trap without vent designed for connection to 2-inch standard galvanized iron pipe.

Hot and cold water connections are to be provided for sink and fitted with $\frac{3}{4}$-inch diameter "Fuller" pattern brass faucets; the cold water faucet to have 1-inch hose connection.

Water supply connections to be galvanized wrought iron fitted with rough brass gate valves.

Shower Bath Fixtures. — The shower bath fixtures in basement and second floor toilet rooms are to be approved pattern, adjustable ball joint, rain shower; face of shower head to be removable and not less than 5-inch diameter. Fixture to be provided with a brass nickel plated non-scalding regulating valve with hand spray attachment; the hand spray to be not less than $3\frac{1}{4}$-inch diameter, with rubber ring, hard wood handle and five feet of best quality rubber tubing, with hook for holding hand spray when not in use. Hand spray attachment to be valved.

Each shower bath fixture to be properly secured in partition between dressing room and shower space and the hot and cold water supply pipes to shower bath are to be provided with brass nickel plated milled wheel, compression stops, with stuffing-boxes.

Drainage from each shower to be through a brass combination floor drain and trap with 2-inch connection to soil pipe; top of cover of floor drain to have hinged strainer cover not less than 9-inch diameter.

The hot and cold water pipe connections to each fixture to be made in the proper manner, and each connection to be fitted with a swing check valve.

All metal fittings and connections of shower bath to be finished brass, heavily nickel plated.

A towel rack same as specified for lavatories and two double coat hooks, same as specified for water closets, must be furnished and securely bolted to marble work in each dressing room; an approved soap holder and a nickel plated tilting sponge basin 11-inch diameter by 5-inch depth must also be furnished and securely bolted to the marble work in each shower bath enclosure. In lieu of tilting sponge basin above noted a $7\frac{1}{2}$-inch diameter brass nickel plated sponge holder may be used.

The above trimmings to be placed where shown on drawing M-48.

Hot Water Boiler and Connections. — A 24-inch diameter by 60-inch long horizontal galvanized steel range boiler is to be furnished and placed where shown on basement plan and supported near the basement ceiling with substantial strap irons.

The boiler is to contain a brass steam pipe coil containing not less than 36 linear feet of 1-inch diameter brass pipe of standard

pipe size and thickness. Steam coil to have inlet at top and outlet at bottom. Steam connections to coil will be made by the heating contractor.

Connections $1\frac{1}{4}$-inch diameter are also to be provided in boiler for cold water supply and hot water discharge; circulating pipe connection is also to be provided and $\frac{3}{4}$-inch diameter connections for safety valve, thermometer and draw-off, also connections for hot water heater. Cold water supply to boiler to be provided with a check valve.

All pipe openings in boiler are to be reinforced, and the boiler and steam coil tested to 150 pounds hydrostatic pressure.

A $\frac{3}{4}$-inch diameter, lever pattern brass safety valve is to be provided, and a $\frac{3}{4}$-inch draw off pipe with gate valve is to be connected into bottom of boiler and run to engineer's sink, the discharge from safety valve to be connected into draw off pipe outside of valve.

Hot Water Heater. — Furnish and connect in basement, where shown on basement plan, one cast iron self contained water heater of approved construction, with fire pot not less than 12-inch diameter.

A smoke pipe of the required size, constructed of No. 20 U.S.G. galvanized iron, is to be provided for heater and connected into smoke breeching from the heating boilers where provision for same will be made by the heating contractor, smoke pipe to be provided with substantial damper and cleanout plug.

Hot water heater must be properly connected to the hot water boiler, connections to be not less than $1\frac{1}{2}$-inch diameter. Flow connection into head of boiler near top, and return connection in bottom of boiler at opposite end.

Fire Hose Connections. — At points indicated on plans 2-inch branch connections are to be taken from the high pressure water main and the 2-inch risers for fire hose connections. Connections to be made about 6 feet from the floor line, and each connection be provided with a 2-inch diameter heavy pattern brass nickel plated angle valve with renewable elastic disc and brass nickel plated hose nipple.

Risers to continue full size, 6 feet above top connection and end capped water and air tight.

Each fire hose connection to have a swinging fire hose reel or swinging hose rack of approved pattern properly secured in place and provided with 75 feet of 2-inch diameter best quality

"Underwriters Standard" unlined very closely woven linen hose, fitted with nozzle and couplings; nozzle and couplings to be finished brass, nickel plated. If hose rack is used hose must hang in vertical loops.

WALL HYDRANTS. — Approved 1-inch diameter brass face anti-freezing wall hydrants with detachable keys are to be provided and properly connected to high pressure water main at points indicated and noted on basement plan. The face plates of wall hydrants to be set flush with outside face of wall.

A gate valve is to be placed on the supply pipe to each wall hydrant, and the supply pipe graded from cut off valve to hydrant so as to drain to outside of building.

PLUMBING MARBLE WORK. — All marble used in toilet rooms and janitors' closets to be best quality hard non-absorbent marble, white or light colored selected stock; free from heavy dark streaks, flaws, or other defects; and must be true and out of wind, cut to the required shapes and lengths, edges square and backs sawed fair and in accordance with drawing M–48.

No marble is to be installed until sample hereinbefore called for has been approved.

The inside of all windows in toilet rooms coming below the top line of marble wainscot are to be of marble.

Marble work in toilet rooms to be finished, bedded and secured in place as specified under "Marble Work."

WAINSCOT FOR TOILET ROOMS. — Marble wainscot to be placed in all toilet rooms and janitors' closets to be $\frac{7}{8}$-inch thick and 6 feet or 4 feet high as indicated or noted on drawings. Wainscot to be bedded, jointed and secured in place as specified under "Marble Work" in construction specification.

MARBLE BORDERS, ETC. — Marble borders for toilet rooms and janitors' closet to be of dimensions given on drawing No. M–48.

Floor borders, etc., to be bedded in mortar composed of equal parts Portland cement and sand.

TERRAZZO FLOORS FOR TOILET ROOMS AND JANITORS' CLOSETS.— All toilet rooms and janitors' closets are to have terrazzo floors with white marble chips which are to be constructed and laid as specified under "Terrazzo Floors," in construction specification.

WATER CLOSET ENCLOSURES, ETC. — Water closet enclosures in toilet rooms, above basement, to be marble and constructed,

supported and braced as shown on miscellaneous drawing No. M–48.

Each water closet enclosure must be provided with a solid paneled door constructed of well seasoned, quarter sawed, clear, selected white oak in accordance with drawing No. M–48. The door must be finished, properly filled and given three coats best quality hard oil finish, first two coats to be rubbed with fine sand paper and last coat rubbed with pumice and oil to a smooth dull finish.

Each door must be hung with a pair of approved heavy pattern hinges with adjustable springs; hinges must be secured to marble work and to doors with socket fastenings and through bolts.

Hinges to weigh per pair not less than 5 pounds.

The spring hinges must be set so as to hold the doors open inside of enclosures.

Each of the enclosure doors must be fitted with a heavy pattern bolt with rubber buffer on handle and each door opening provided with a stop with rubber faced buffer.

The partitions between water closets in the toilet room in the basement are to be marble 2 feet 1 inch x 5 feet x $1\frac{1}{4}$ inches thick, set 1 foot above floor; supported and secured in place as shown by dotted outline on drawing No. M–48.

Urinal Partitions, etc. — The partitions, backs, caps, etc., for urinals to be of marble, constructed and braced as shown by detail on miscellaneous drawing No. M–48.

Openings required for passage of pipes through marble backs and cap pieces to be neatly cut, and the pipes passing through same to be fitted with ornamental collars.

Bath Enclosures. — The marble partitions forming shower bath enclosures and dressing rooms in connection with same in basement and second floor toilet rooms must be constructed, supported and braced as shown on drawing No. M–48.

Joints in marble work of shower bath enclosure and between the floor drain and marble floor slab must be made water-tight with cement composed of glycerine and litharge.

The marble floor slab in the shower bath enclosure of the second floor toilet room is to be set in a 4-pound sheet lead pan. The top of marble slab must be set 1 inch below the finished level of dressing room floor and must extend under the wainscot, sill and partition. The lead pan is to be turned up outside the

slab, with edges flush with finished floor, and must be soldered tight around floor drain.

A finished quartered oak corner seat, 18 inches x 18 inches x $1\frac{1}{4}$ inch thick must be furnished in each dressing room as indicated; seats to be supported on two heavy pattern brass nickel plated angles securely bolted to the marble work.

Entrance to dressing rooms must be provided with finished four paneled doors 2 feet 2 inches wide by 6 feet high, hung 4 inches above the floor. Doors to be constructed and finished similar to water closet enclosure doors and hardware to be the same.

Trimmings for Marble Work. — All metal fittings in connection with marble work, hardware for enclosure doors, etc., to be finished brass heavily nickel plated, all pipe standards and bracings to be annealed seamless drawn brass tubing, not less than No. 16 Brown and Sharp gauge, polished and nickel plated.

The framing flanges to be secured to floor and brick walls with expansion bolts and to terra cotta partitions with through bolts with flat heads or washers so that same can be concealed by plaster.

GAS PIPING.

The contractor is to put in place complete the system of gas piping for supplying all the lights indicated on the drawings.

The gas fixtures, except the lamp standards at Riverside Avenue entrance will not be included in this contract.

The gas outlets must be arranged so as to allow placing of electric conduit boxes for combination fixtures.

The contractor must pay all fees and charges for bringing a 4-inch diameter gas supply pipe into the building, leaving capped outlet where indicated. This contractor must furnish and place at curb line a stop cock or tee handle gate valve on gas pipe, also a cast iron extension stop cock box, located as directed. Gas main just inside of basement wall to be provided with a brass gas cock. The gas pipes in building to be "Standard" gauge black wrought iron, and all fittings to be galvanized malleable iron beaded fittings. The kind of pipe used from street main to building and manner of laying to be in accordance with regulations of local gas company. A cast iron pipe sleeve extending through foundations of steps to the inside of building wall is to be provided for gas main as shown on the basement plan.

The size of gas pipes to be in no case less than sizes given in the following schedule, except in basement, where the sizes marked on drawings must be installed. There will also be two 3-inch main gas risers as shown.

The gas meter will not be furnished or set under the contract:

Size of Pipe, Inches.	Greatest Length Allowed, Feet.	Greatest Number of Burners.
$\frac{1}{2}$	30	5
$\frac{3}{4}$	50	20
1	70	35
$1\frac{1}{4}$	100	65
$1\frac{1}{2}$	150	100
2	200	200
$2\frac{1}{2}$	300	300

The main gas pipe of size given on basement plan to start at point indicated with capped inlet near basement ceiling, run along same to vent shaft, up vent shafts and at each story to have branches of sizes proportionate to the number of outlets and lights to be supplied.

The gas mains and branches thereto to be supported close to basement ceiling with wrought iron or malleable iron hangers and securely supported in shaft in an approved manner.

Risers to brackets in plastered rooms to be recessed into walls so as to be entirely concealed by plaster. Gas pipes in basement and in attic space are to be run exposed. All other gas pipes to be concealed, excepting those for lights on bottom of 15-inch girders forming skylight framing over first floor P. O. workroom, which will be run exposed on underside of girders.

The pipes supplying bracket lights in each story and ceiling lights in story below are to be run in the construction of that floor.

Gas outlets for bracket lights to be set approximately 7 feet above floor. Supply pipes for P. O. screen lights to be taken from main near basement ceiling at points indicated and run up concealed in screens and along same in space provided, about 7 feet above floor, with outlets at approximately that height at points indicated.

All pipes to be run level where possible, and are to be without traps, and at foot of main riser is to be placed a "T" fitting and piece of pipe of same size with reducing fitting connected to the bottom of "T" for the purpose of collecting drip and scales; a short piece of $\frac{3}{4}$-inch pipe with a gas cock to be screwed to reducing fitting so that drip can be drawn off when necessary.

The supply branches to each exterior lighting fixture (except lamp bracket at mailing platform), the screen lights and the main supply branch to each floor are to be fitted with gas cocks, so that supply to said lights can be controlled. Cocks must be placed where indicated or directed, easily accessible.

If conditions require that controlling gas cocks be located in floor construction, they must be set in a pocket and over said pocket a finished cast brass plate is to be set and secured in place with screws so that it may be removed for access to gas cocks.

The gas outlets for all vaults are to be taken from gas pipe below floor and run in wall alongside of vault door as indicated to a distance of 5 feet above floor line, outlets to extend just beyond finished plaster line as hereinafter specified and end to be capped.

A plugged outlet of size given is to be provided on gas main in basement at point indicated, for connection to special furniture fixtures which will be placed in the future.

Especial attention of the contractor is called to the gas nipples for fixtures which must be at right angles to the walls and ceilings from which they project and must project from finished plaster line of ceiling not less than $\frac{3}{4}$ inch nor more than $1\frac{1}{4}$ inches and from finished plaster line of walls not less than $\frac{1}{2}$ inch nor more than $\frac{3}{4}$ inch and to be properly fitted and capped.

No branch pipe from main to be less than $\frac{1}{2}$-inch internal diameter.

Outlets for all brackets, vault outlets and drops for all chandeliers containing four (4) lights or less are to be $\frac{3}{8}$-inch diameter, drops for chandeliers containing 5 lights and not exceeding 10 lights to be $\frac{1}{2}$-inch and for greater than 10 lights, drop is to be $\frac{3}{4}$-inch diameter.

Drops for chandeliers to come from a centre of a "T" branch, and where a chandelier occurs at the end of a run of pipe the extra opening in the tee is to be fitted with a capped 12-inch length of pipe in order to form a support for fixture.

All gas pipe to be run regularly and in a workmanlike manner,

using all necessary fittings, and in no case springing or bending the pipe to reach a point desired.

Pipe and fittings to be put together with red lead, litharge or any approved compound.

No gas fitters' cement will be allowed except at outlet caps.

After all gas piping has been completed, tested and approved, all gas pipe (including pipe buried in walls and floors) in the building must be cleaned and given one coat of best quality asphaltum paint.

Testing. — The entire system of soil, waste, drain and vent piping in the building is to be tested with water before the fixtures are connected. Openings are to be plugged where necessary and the entire system filled with water to the level of the roof gutters and allowed to stand for six hours for inspection, after which, if test is satisfactory, the trenches are to be filled and fixtures connected.

The 8-inch sewer connection between building and city sewer must be tested before the immediate connections are made to sewer by filling the same with water to top of temporary sections of pipe about 10 feet high above basement floor line, connected to the end of lines just inside of the building. The lines proved absolutely tight to the satisfaction of the Superintendent, after which water may be drawn off, the connections made to city sewer and trenches back filled.

After the fixtures have been connected the smoke test is to be applied to the sanitary system, and the entire system proved tight when filled with smoke under pressure equal to one inch of water, to the satisfaction of the Superintendent.

At the completion of the work the water supply system is to be tested to a hydrostatic pressure of 150 pounds to the square inch.

The entire gas pipe system inside of building must be tested with air pressure equal to 15 inches of mercury as soon as laid; also before the last coat of plaster is put on, and again on completion of the plastering.

Costs of tests to be borne by the contractors, who must furnish this office, through the Superintendent, with certificate that satisfactory tests have been made. The certificate must be signed by the Superintendent.

Various Receipts and Short Cuts.

Miscellaneous Receipts. — Test for Sewer-gas. — Saturate unglazed paper with a solution of 1 ounce pure lead acetate in half a pint of rain-water; let it partially dry, then expose in the room suspected of containing sewer-gas.

The presence of gas in any considerable quantity soon darkens or blackens the test-paper. A suspected joint of a pipe can be tested by wrapping with a single layer of white muslin, moistened with the above solution, and if gas is escaping it will darken the cloth.

To Clean Copper.—Take 1 ounce of oxalic acid, 6 ounces of rotten stone, ½ ounce of gum arabic, all in powder, 1 ounce of sweet-oil, and sufficient water to make a paste. Apply a small portion and rub dry with a flannel or leather.

Removal of Stains from Granite. — A paste of 1 ounce of ox-gall, 1 gill of strong solution of caustic soda, 1½ tablespoonfuls of turpentine, with enough pipe-clay to make it thick, and scour well.

Or, mix together ¼ pound soft soap, 1 ounce washing-soda, and a piece of sulphate of soda as big as a walnut. Rub it over the surface proposed to clean, let it stand twenty-four hours, and then wash off; or, smoke and soot stains can be removed with a hard scrubbing-brush and fine sharp sand, to which add a little potash.

Or, use strong lye, or make a hot solution of 3 pounds of common washing-soda dissolved in 1 gallon of water. Lay it on the granite with a paint-brush.

To Clean Marble.—Mix 2 parts by weight of sal-soda, 1 part powdered chalk or fine bolted whiting, and 1 part powdered pumice-stone with enough water to make a thin batter, and by the means of a scrubbing-brush apply it to the spots; then wash off with soap and water.

Or, to remove grease spots from marble, moisten fine whiting or fullers' earth with benzine, apply it in a thick layer to the spots, and let it remain for some time; then remove the dry paste and wash the spot with soap and water.

To extract oil stains from marble, make a paste by mixing 2 parts of fullers' earth, 1 part soft soap, and 1 part potash with

boiling water. Apply this paste to the spots and let it remain three or four hours.

To Remove Paint from Window Glass.—Put sufficient saleratus into hot water to make a strong solution, and with this saturate the paint which adheres to the glass. Let it remain until nearly dry, then rub it off with a woollen cloth.

To Make Modelling Clay.—Knead dry clay with glycerine instead of water, work thoroughly with the hands, moisten work at intervals of two or three days, and keep covered to prevent evaporation of moisture.

To Clean Paint.—When paint is washed with any strong alkaline solution, such as soda or strong soap, the oil of the paint is liable to be changed to soap and the paint is seriously injured. To avoid this, take some of the best whiting, and have ready some clean warm water and a piece of flannel, which dip into the water and squeeze nearly dry; then take up as much whiting as will adhere to it, apply it to the painted surface, when a little rubbing will quickly remove any dirt or grease stains. After this wash the part well with clean water, rubbing it dry with a soft chamois. Paint thus cleaned will look as well as when first put on, and the operation may be tried without fear of injury to the most delicate colors. It answers far better than the use of soap, and does not require more than one-half the time and labor. Another simple method is the following: Put a tablespoonful of aqua ammonia in a quart of moderately hot water, dip in a flannel cloth, and with this merely wipe over the surface of the woodwork. No rubbing is necessary. The first recipe is preferable, except where the paint is badly discolored.

To Age or Color Copper.—Add about 1 pound of powdered sal ammoniac to 5 gallons of water, dissolve it thoroughly, and let it stand at least twenty-four hours before putting it on the copper. Apply it to the copper with a brush, being sure to cover every place; let it stand for a day and sprinkle with water, using a brush to sprinkle the water on so that it will not run and streak the copper. After standing overnight the color will be as desired. The same effect can be produced by using vinegar and salt instead of the sal ammoniac, using ½ pound of salt to 2 gallons of vinegar.

To Remove Old Glass from Sash.—Take a hot iron and run along the surface of the putty, when it can easily be removed with a chisel.

Pitch of Roofs.—With a view to aiding those in the trade who have more or less roofing to do the St. Paul Roofing, Cornice & Ornament Company has issued a table giving the minimum pitch of roofs in inches to the foot for the following kinds of roofing materials.

Asphalt and composition	$\frac{1}{2}$
Tin	1
Corrugated iron	3
Sheet iron	3
Copper	2
Lead	2
Thatch	6
Shingles	4
Slate	4
Tiles, terra-cotta	4

To Clean Brass (U. S. Government Method).—Make a mixture of one part common nitric acid and one-half part sulphuric acid in a stone jar, having also a pail of fresh water and a box of sawdust. Dip the articles into the acid, then soak them in the water, and finally rub them in sawdust and they will take on a brilliant color. If the brass is greasy it must be first dipped in a strong solution of potash and soda in water, and then rinsed, so that the grease may be removed, leaving the acid free to act.

Belting.—Horse-power of a belt equals velocity in feet per minute multiplied by the width; the sum divided by 1000. One inch single belt moving at 1000 feet per minute = 1 horse-power. Double belts about 700 feet per minute per 1 inch width = 1 horse-power. For double belts of great length, over large pulleys, allow about 500 feet per minute per 1 inch of width per horse-power. Power should be communicated through the lower running side of a belt; the upper side to carry the slack. Average breaking weight of a belt, $\frac{3}{16} \times 1$ inch wide: leather, 530 lbs.; three-ply rubber, 600 lbs. The strength of a belt increases directly as its width. The coefficient of safety for laced belts is: leather $= \frac{1}{16}$ breaking weight; rubber $= \frac{1}{8}$ breaking weight.

To Find the Diameter of a Pulley for any Speed.—Multiply diameter of pulley on main shaft by the revolutions of main shaft and divide by the number of revolutions (or speed) re-

quired, the quotient will be the diameter in inches of required pulley.

Flux for Soldering Zinc.—Dissolve small bits of zinc, or zinc drops, in muriatic acid, mixed with an equal bulk of water.

To Make Chimneys Soot-proof.—To make chimneys soot-proof use salt in the mortar to plaster the flues, one part of salt to three of lime.

To Lead Hinges, etc., in Stone.—In leading hinges into stone if a few drops of oil is put in the hole before running in the molten lead it will prevent the lead from flying or exploding.

To Bend Lead Pipe.—Fill the pipe with dry sand, plug each end, and bend into the desired shape.

Paint for Shingles.—A good paint for shingles is made by heating one barrel of coal-tar, 10 pounds asphaltum, 10 pounds ground slate, and 2 gallons dead oil; add the oil after heating the mixture.

Varnish for Pattern Work.—Shellac cut with grain alcohol is the best varnish for pattern makers. Put the gum in a glazed earthenware jar and cover it with grain alcohol. For fine light work add a little more alcohol. Never add oxalic acid to the varnish to clear it when old. Rather throw it out and prepare a fresh supply.

To Distinguish Steel from Iron.—To distinguish steel from iron apply a drop of nitric acid and let it remain for a moment, then rinse with water. If the metal is iron a whitish-gray spot will remain; if steel, a black stain.

Filling-wax for Granite.—A filling that is used to fill up holes, etc., in granite monuments, is made by melting gum dammar in a shallow vessel over a bath of water, so as not to burn it. When quite thin stir in granite dust, and add enough marble dust to lighten it to the color of the granite. Stir in all the dust the gum will easily hold; roll out into long sticks, and it is ready for use. To apply heat an iron red hot and hold it over the stone, and at the same time hold the stick near the monument and it will melt, and can then be pressed into the cavity. When cold pare down with a sharp tool and touch up lightly with a bush-hammer or chisel.

To Toughen Plaster-casts. — To toughen plaster-casts immerse them till well saturated in a hot solution of glue. When treated in this way a nail can be driven into them without cracking them.

Impression-wax. — To make squeezing-wax for taking reverse impressions of carvings, mouldings, or other work take 9 ounces of beeswax, 12 ounces lard, 3 ounces olive-oil, and 5 pounds whiting (or in like proportion). Melt the three former ingredients together, then add the whiting, pounding it up well before mixing. When cold knead well together with the hands; or, take ½ pound of hogs' lard, ½ pound of beeswax, 2 pounds of flour, 1 gill of linseed-oil; melt all down. If too sticky add more flour; if too hard melt down again and add a little more lard.

Moulds for Plaster-casts.—Take the very best glue you can get, place it in cold water at night, the next morning take it out; you will find it swollen; the water it has absorbed during the night is sufficient to melt it by heat; mix then as much thick glycerine with it as you had glue, and keep the vessel containing them in a steam- or water-bath till all the water is about evaporated and there is left as much in weight as the weight of the dry glue and glycerine taken together amounted to. This will make a compound of glue and glycerine which will never dry, and a mould of it can be used over and over again.

To Clean Metals.—Copper, brass, zinc, and other metals are cleaned by the suitable acids which act on them. Such cleansing solutions may be prepared for the different metals as follows:

	Water.	Nitric.	Sulphuric.	Hydro-chloric.
For copper and brass.	100	50	100	2
Iron.	100	3	8	2
Iron (cast).	100	3	12	3
Zinc.	100	. .	10	
Silver.	100	10		

It is best to make two such solutions, one being reserved for a final dip or wash; as this becomes weaker it can be used for the first wash, accompanied by occasional rubbing with sand, etc., according to the nature of the object being cleaned.

Paper under Tin.—Tar or asphalt paper should never be used under a tin roof, as there is an acid which comes from the paper which destroys the tin. When paper is used under tin it should be a paper that will not draw dampness. A thick layer

of paper should be put under all tin laid on concrete, to form a cushion and prevent any sharp projections from cutting the tin.

To Find the Power of a Lever.—*Rule.*—As the distance between the weight and the fulcrum is to the distance between the power and the fulcrum so is the power to the weight.

To Find the Power of Pulleys or Set of Blocks.—*Rule.*—As one is to twice the number of movable pulleys so is the power to the weight.

Size of Gutters and Down-spouts or Conductor-pipes.—A rule of the American Bridge Company requires the following sizes for gutters and conductor-pipes:

Size of Roof.	Gutter.	Conductor.
Up to 50 feet	6 inches	4 inches every 40 feet
50 " 70 "	7 "	5 " " 40 "
70 " 100 "	8 "	5 " " 40 "

Paste for Paper to Iron. For pasting paper to iron or steel mix dextrine with water and boil it down until it assumes about the consistency of very thin glue; it will not hold on greasy or oily substances.

Ink for Zinc.—An ink which can be used with a drawing-pen on zinc and which is acid-proof is made of 1 dram verdigris, 1 dram sal-ammoniac powder, and ½ dram lampblack, mixed with 10 drams of water.

Oil for Oil-stones.—A good oil for oil-stones is made by mixing equal parts of sperm- and carbon-oil (coal-oil).

Nailing in Hardwoods. — When working in hardwoods bore a hole in the end of the hammer-handle and fill with soap or beeswax. When a nail is to be driven place the point of it in the beeswax or soap and it will drive much easier.

Penny as Applied to Nails.—The term " penny " is derived from pound. It originally meant so many pounds to the thousand. Threepenny nails would mean three pounds to the thousand nails; eightpenny nails, eight pounds to the thousand nails, etc.

To Mark Tools, etc.—Take 7 ounces of nitric acid and 1 ounce of muriatic acid; mix, and shake together, then cover the tool where it is desired to mark with beeswax, and take a needle or other sharp instrument and scratch the name plainly in the beeswax; then apply the acid with a feather, filling up the scratch in the wax; let it remain for about five minutes, then wash off with water and rub with oil.

Paste or Putty for Castings. — Eighty parts of sifted cast-iron turnings, two parts of powdered sal-ammoniac, and one part sulphur, made into a thick paste with water and mixed fresh for use, makes a good cement for stopping holes in castings.

Fine Lubricating-oil. — Put pure olive-oil into a clear glass bottle with strips of sheet lead and expose it to the sun for two or three weeks; then pour off the clear oil, and the result is a lubricant which will neither gum nor corrode. It is used for watches and fine machinery of all kinds.

To Remove Paint or Grease from the Hands. — Paint or grease is most readily removed from the hands by taking a handful of fine sawdust, saturating it thoroughly with kerosene, and scrubbing them in it, then rubbing them dry in plenty of dry sawdust.

To Keep Water in Paint-troughs from Freezing. — The water in brush-troughs can be kept from freezing in cold weather by the addition of salt or a little glycerine. Neither will hurt the brushes.

How to Clean Tracings. — Tracings that are badly soiled with grease spots or other dirt may be nicely cleaned with kerosene. Tack the tracing to a board and apply the kerosene gently but liberally to the surface, allowing it to soak a short time, and then drying off with a clean rag. Turn the tracing over and treat the other side in the same manner. Place in a warm place to dry. Naphtha or benzine will also answer the same purpose.

Height of Privy-seats. — Privy-seats should be set about 15 inches in height.

Height of Wash-tubs. — Wash-tubs are usually set about 31 inches from the floor to the top of the tub.

Height of Wash-stands. — Wash-stands are usually set 2 feet 6 inches from the floor.

Height of Horse Troughs. — Horse or cattle water-troughs should be set about 26 inches from the floor or ground to the top of the trough.

Height of Sinks. — Sinks are usually set about 2 feet 6 inches from the floor to the top of the sink.

Dimensions of Bath Tubs. — The dimensions of bath tubs vary according to the style and manufacture, about as follows:

In width over all, they run from 25 to 35 inches.
In height, including legs, they run from 22 to 25 inches.
In depth inside, they run from 16 to 19 inches.
In length, they are made 4 feet, 4 feet 6 inches, 5 feet, 5 feet 6 inches and 6 feet, over all, and some makes will run 2 inches longer than the above sizes.

LIFE OF IRON PIPE. — The life of wrought iron pipe was recently discussed in *Building News*. It seems that in 1890 several cast iron conduits at Berlin, from 3.5 to 10 cm. in diameter, were ruptured, which led the authorities to replace the cast iron pipes with those of wrought iron, covered with the following composition for protection: Sixty-five kg. (143 pounds) of tar, 3 kg. of rosin (6.6 pounds), 15 liters (4 gallons, or 0.53 cubic feet) of sand, 7 liters (1.85 gallons) of loamy clay and 4 liters (1 gallon) of powdered lime. A coating of this mixture, 3 or 4 mm. thick ($\frac{1}{8}$ to $\frac{5}{32}$ inch), was applied. In more than a dozen years of service these pipes have been preserved from rust and have undergone no change.

SOLDER. — The essentials of a good solder are that it shall have an affinity for the metals to be united, should melt at a considerably lower temperature, should be strong, tough, uniform in composition, and not easily oxidized.

Before selecting a solder be sure to thoroughly acquaint yourself with the requirements and choose a solder suited for the purpose. A solder with a low melting point, though the initial cost be a trifle more, will give better satisfaction than the solder with a high melting point, and if properly handled will be cheaper in the end. A solder with a low point of fusion saves reheating of irons and enables the workmen to run a greater quantity of metal before the copper chills, flows free, thus causing a greater space to be covered than with an equal bulk of a coarser grade. A wiping solder should not have too low a melting point, but should undergo a prolonged pasty stage on cooling. It is upon this quality that the workman depends for success in wiping a joint.

TO MAKE WIPING SOLDER. — Wiping solder is made by melting together three parts lead and two parts tin, but this will vary according to the quality of the lead and tin. After it is melted it can be tempered by adding lead or tin. If after being melted the mixture cools with a sort of mottled appearance, it is

about right for use; if very bright it has too much tin; if very dull it has too much lead.

To Remelt and Refine Old Solder. — Place the solder in a pot, melt and add a little new tin, try the solder at intervals by soldering a seam; in this way the tin can be added in small quantities until the solder works as desired. A little sulphur helps with the operation.

Old wipe joints can be remelted and tin added in this manner until the metal is the right fineness for use again.

Solder for Soldering Aluminum. — Aluminum, 30 per cent; tin, 38 per cent; zinc, 40 per cent; paraffine, wax, or fat, 2 per cent. This solder may be used without a flux.

Zinc, 30 per cent; bismuth, 5 per cent; tin, 65 per cent; with zinc chloride as a flux.

Aluminum, 8 to 20 per cent; zinc, 80 to 92 per cent. Melt the aluminum first, then add zinc gradually; finally add a little fat.

For a flux use 3 parts copaiba balsam, 1 part Venice turpentine, and a few drops of lemon juice.

Universal Soldering Fluid. — A soldering fluid which will not rust or corrode the soldered parts is made by dissolving as much zinc in muriatic acid as the acid will take up and then adding water, glycerine and alcohol.

To one part glycerine add one part alcohol and one part of water; then add two parts of acid with the zinc dissolved.

Improved Acid — Zinc Soldering Flux. — To make 1 gallon of this soldering fluid take 3 quarts of common muriatic acid and allow it to dissolve as much zinc as it will take up. This method, of course, is the usual one followed in the manufacture of ordinary soldering acid. The acid, as is well known, must be placed in an earthenware or glass vessel. The zinc may be sheet clippings or common plate spelter broken into small pieces. Place the acid in the vessel and add the zinc in small portions so as to prevent the whole from boiling over. When all the zinc has been added and the action has stopped, it indicates that enough has been taken up. Care must be taken, however, to see that there is a little zinc left in the bottom, as otherwise the acid will be in excess. The idea is to have the acid take up as much zinc as it will.

After this has been done there will remain some residue in the form of a black precipitate. This is the lead which all zinc contains and which is not dissolved by the muriatic acid. This lead

may be removed by filtering through a funnel in the bottom of which there is a little absorbent cotton, or the solution may be allowed to remain over night until the lead has settled and the clear solution can then be poured off. This lead precipitate is not particularly injurious to the soldering fluid, but it is better to get rid of it so that a good, clear solution may be obtained.

Now dissolve 6 ounces of sal-ammoniac in a pint of warm water. In another pint dissolve 4 ounces of chloride of tin. The chloride of tin solution will usually be cloudy, but this will not matter. Now mix the three solutions together. The solution will be slightly cloudy when the three have been mixed, and the addition of a few drops of muriatic acid will render it perfectly clear. Do not add any more acid than is necessary to do this, as the solution would then contain too much of this ingredient and the results would be injurious.

This soldering acid is used in the same manner as any solution of this kind, but it will be found that it will not spatter when the iron is applied to it. It has also been found that a poorer grade of solder may be used with it than with the usual soldering acid.

Soldering Fluids. — 1. Muriatic acid with zinc dissolved in it until it will take no more.

2. Dissolve zinc in hydrochloric acid until the acid will take no more; then dilute with water.

3. Take one ounce of grain alcohol, 1 ounce glycerine, ½ ounce chloride of zinc and mix together. This flux will not stain or corrode the work.

Linseed Oil as a Flux. — Linseed oil can be used as a flux for roof work. The oil is not quite as fast as rosin or acid, but it leaves nothing objectionable to be dealt with afterwards. Acid runs into the seams and causes corrosion, while rosin is extremely hard to remove.

Flux for Tinware. — Mix together one dram each of borax, copperas, and yellow prussiate of potash, ½ dram sal-ammoniac and 3½ ounces of muriatic acid.

Powder the chemicals and let all cut the zinc; then add three times as much water.

Flux for Copper and Bronze. — Mix pulverized cryolite and a solution of phosphoric acid, in spirits of wine.

Soldering Cast Iron. — The surfaces to be united should be made bright and clean; they should then be tinned separately and sweated together. The pieces should be kept hot while

being sweated together and pressed together closely while cooling. It is very difficult to solder some of the finer grained cast irons.

To clean the iron before soldering file it until it becomes bright, then brush it with a wire brush until the iron becomes yellow; this will facilitate the soldering.

Flux for Brazing Steel. — Take 1 part by weight of borax, melt in a ladle and after it cools reduce to a powder; then add 3 parts by weight of boracic acid and mix to a paste with water.

How to Make Soldering Paste. — Soldering paste, says the "Brass World," has now come into extensive use in electrical work as a flux for soldering. This has been brought about by the requirements of the electrical trade that in certain forms of soldering no acid shall be used. For soldering copper wires for electrical conductors, soldering paste is almost exclusively used. It has also entered other fields of soldering, particularly in instances where spattering and corrosion are objectionable.

Soldering paste which is now used in the electrical trades consists of a mixture of a grease and chloride of zinc. The grease which is commonly used is a petroleum residue, such as vaseline or petrolatum. Such a material is about right in consistency. The proportions which are used are as follows:

Petrolatum	1 lb.
Saturated solution chloride of zinc	1 oz. (fluid).

The use of petrolatum instead of vaseline is recommended. While they are identical in composition, the name "vaseline" is registered as a trademark and commands a higher price on this account. Petrolatum is much cheaper.

The chloride of zinc solution is made by dissolving as much zinc in strong muriatic acid as it will take up. An excess of zinc should be present and all the acid neutralized. This will form a thick, oily solution. The petrolatum and chloride of zinc are mixed and thoroughly incorporated by means of a mortar and pestle or by vigorous stirring.

The advantage of this soldering paste lies in the fact that it does not spatter and is not corrosive. It will be found excellent and is now extensively used.

To Keep Hot Lead from Sticking. — Prepare a mixture of 1 qt. powdered charcoal, ½ pt. salt, 1 gill yellow prussiate of potash and a lump of cyanide of potassium the size of a walnut. Apply this to the surface of the pot or to tools to be heated in the molten metal.

WOOD RIMS ON SINKS AND BATH TUBS. — Wood rims should never be used on sinks or bath tubs, as they are only a breeder of dirt and disease; but if for any reason they are used they should be bedded in a layer of soft putty, so as to completely stop the crack between the rim and the fixture and prevent the accumulation of dirt under the rim.

TO ESTIMATE THE HORSE POWER OF A GAS ENGINE. — The horse power of a high grade four-cycle gas engine may be closely estimated by the following rule.

Each square inch of the area of the piston head will give about $\frac{7}{16}$ of a horse power. This rule applies only when the engine is in perfect condition, igniting correctly, etc., running at about 250 revolutions per minute.

HORSE POWER OF WINDMILL. — To calculate the horse power of a windmill approximately, multiply the area of the slats in the plane of revolution by the cube of the velocity of the wind in feet per second, and divide the product by 4,000,000.

HORSE POWER OF STEAM ENGINE. — To find the horse power of a steam engine, multiply the square of the diameter of the cylinder in inches, by 0.7854, and this product by the mean engine pressure, and the last product by the piston travel in feet per minute. Divide the last product by 33,000 for the indicated horse power. In the absence of any logarithmic formula or expansion table, multiply the boiler pressure for $\frac{5}{8}$ cut off by 0.91; for $\frac{1}{2}$ cut off by 0.85, for $\frac{3}{8}$ cut off by 0.75; for $\frac{3}{10}$ cut off by 0.68. This will give the mean engine pressure per square inch near enough for ordinary practice, for steam pressures between 60 and 100 pounds.

Always remember that the piston travel is twice the stroke multiplied by the number of revolutions per minute.

CEMENTS FOR STEAM AND WATER JOINTS. — 1. Black oxide of manganese mixed with sufficient raw linseed oil to bring it to a thick paste. Remove pressure from pipe and keep warm enough to absorb the oil while the cement is being applied to the joint or leak.

2. With boiled linseed oil mix together to the consistency of putty the following ingredients: Ground litharge, 5 lbs.; plaster of paris, 2 lbs.; yellow ochre, $\frac{1}{4}$ lb.; red lead, 1 lb. If a binder is desired, mix in a little hemp cut to $\frac{1}{2}$-inch lengths.

3. White lead, 10 parts; black oxide of manganese, 3 parts; litharge, 1 part. Mix with boiled linseed oil.

Steam Fitters' Cement.—The following formula for steam fitters' cement was presented by S. S. Sadtler in a paper read recently before the Engineers' Club of Philadelphia. The body of the cement consists of either red or white lead. The red lead is often diluted with an equal bulk of silica or other inert substances so as to make it less powdery. The best way that I have found to do this, however, is to add rubber or gutta-percha to the oil as follows: Linseed oil, 6 parts by weight; rubber or gutta-percha, 1 part by weight. The rubber or gutta-percha is dissolved in sufficient carbon disulphide to give it the consistency of molasses, mixed with the oil, and left exposed to the air for about 24 hours. The red lead is then mixed to a putty. Oxide of iron makes a less brittle cement than red lead. Probably fish oils and red lead would make good cements of the class for joining pipes, as the fish oils are not such strong drying oils as linseed, and their use might be a case of permissible substitution rather than adulteration.

Cement or Putty for Making Waste Connections to Marble.—When making a waste connection to a marble slab, as in shower baths, use a cement or putty made of equal parts of white lead and whiting.

Cement for Repairing Wash Trays, etc.—A very strong cement, which sets very hard, and which is used in repairing wash trays, etc., is made by mixing litharge and glycerine together.

Cement for Attaching Metal Letters to Glass.—Use 30 parts copal varnish, 10 parts spirits of turpentine, 10 parts glue dissolved in a little warm water, and 20 parts pulverized slaked lime.

Cement for Joints.—Take paris white, ground, 4 pounds; litharge, ground, 10 pounds; yellow ochre, fine, $\frac{1}{2}$ pound; $\frac{1}{2}$ ounce hemp, cut short; mix well together with linseed oil to a stiff putty. This cement is good for joints on steam and water pipes, and will set under water.

Aquarium Cement.—(1) Whiting, 6 parts; plaster of paris, 3 parts; white sand, 3 parts; litharge, 3 parts; powdered resin, 1 part. Mix thoroughly, and make into a putty with the best coach varnish. Let the glass stand about a week before putting in water.

(2) Linseed oil, 3 ounces; tar, 4 ounces; resin, 1 pound; melt together over a gentle fire. If too much oil is used the cement

will be too thin and run. It is best to try a little on a piece of glass, which should be put under water. If too thin let it simmer awhile or add a little more resin. When used, the glass of the aquarium should be slightly warmed.

Gas Fitters' Cement. — Melt together 4½ parts resin (by weight), 1 part beeswax; then stir in 3 parts Venetian red and pour into moulds made of oiled paper or iron.

What a Leak in a Water Pipe Amounts to. — Water dropping at the rate of 35 drops per minute amounts to ½ pt. per hour, or 1½ gal. every 24 hours.

Cleaning a Water-Back. — In some instances where the water used contains much lime the water-back of a stove or heater will become clogged with a sediment of calcium carbonate.

This can be removed with a solution of muriatic acid, which should be poured into the water-back and allowed to stand for a couple of hours; the solution should then be poured out and the water-back washed out with clean water.

To Tin a Soldering Iron. — Dress the iron down by filing; then take a soft clay brick and rub one side with the iron until there is a small depression or hollow; put a few small pieces of solder and resin in the hollow; then heat the iron to a working heat and rub it into the solder. If the solder does not stick readily use a solution of sal-ammoniac water.

To Prevent Iron from Rusting. — Dip the metal for a few moments in a solution of blue vitriol, and then in a solution of hyposulphite of soda, acidulated with chlorhydric acid. This will give a blue-black color to the metal.

To Locate Crooked Threads. — If, when a piece of pipe is screwed into a fitting, it is out of line, it is a very simple matter to determine, by turning the pipe a half-turn, whether the crooked thread is in the fitting or in the pipe. If the pipe still maintains its crooked position, then the crooked thread is in the fitting; but if the pipe turns to a different slant as it is turned around, then the crooked thread is on the pipe.

Crooked threads on pipe are usually threads that are cut by dies in stocks, and are caused by the fact that the distance between the die and the bushing is too short. In cases where the bushing is badly worn, the die is just as apt to cut a crooked thread as a straight one, as the bushing does not keep the die at right angles to the pipe.

Height to which a Siphon will Lift Water. — The height of water which atmospheric pressure at sea level will sustain is about 33.8 feet. This is theoretical and would only occur if there was a perfect vacuum above the water column.

When the flow of water takes place the friction of the pipes offers resistance, so all things taken into consideration, the lifting power of a siphon is from 25 to 28 feet.

Flow of Water from Elevated Tanks. — If an elevated tank has two outlets, the pipes being the same size, but one pipe being considerably longer than the other, the long pipe will discharge the most water, as the weight of water in the longer pipe has a tendency to create a vacuum in the pipe and thus causes a greater suction from the tank.

To Clean Zinc. — To clean tarnished zinc apply with a rag a mixture of one part sulphuric acid with twelve parts of water. Rinse the zinc with clean water.

To Prevent Clay, etc., from Sticking to the Shovel. — When shoveling sticky clay or mud, if several holes are drilled through the blade of the shovel they will let the air in and prevent the clay or mud from sticking, caused by the suction against the blade of the shovel.

Height to which Water Can Be Lifted by Suction. — A pump will lift water by suction to the same height it can be lifted with a siphon, 25 to 28 feet, and no more, as they both work on the same principle, that is, the pressure exerted by the atmosphere.

Care of Fixtures in Vacant Houses. — When a house is to stand vacant during the winter months, and there may be any danger of the water seal in the traps of the fixtures freezing and breaking the fixture, the water should all be drawn off and the seal made with oil, as this will not freeze and will keep the trap sealed so that no sewer gas can enter the house.

Plumbers' Soil. — Plumbers' soil which is used for coating pipe, etc., when soldering or making a "wipe" joint is made of glue and lampblack; the glue should be made very thin with water, and the lamp black added, the mixture being allowed to simmer for about 15 minutes until it is of about the consistency of paint. If it rubs off easily add more glue, but if it comes off in flakes it has too much glue.

Finishing Asbestos Covering. — When putting plastic asbestos covering on boilers, etc., after the body of asbestos is put

on, cover with a skim coat mixed with about one-half Portland cement; this will give a hard, smooth finish.

To Cast a Lead Plumb Bob. — Take a large egg and cut a small hole in the end of the shell, where the eye of the bob will be; then cut another hole in the side of the shell to be used to pour in the molten metal. The contents of the shell can now be drawn out, and the shell should be laid away until perfectly dry. When dry put the shell in a small box and completely surround and cover it with clay or sand, putting the wire eye in place as the shell is covered, so that the clay will hold the eye in position. The hole in the side of the shell should be at the top and the clay worked up around it so as to form a sort of funnel in which to pour the hot lead. Pour the shell full, and when cold break away the clay and shell.

Collecting Spilled Mercury. — Mercury spilled on the floor or work bench is very hard to collect, as it separates into small globules which roll away at the slightest touch. A simple method to assist in the collecting of the mercury is to make a wet ring around the mercury and then gather it up on a card, scoop or in an envelope. The mercury will not readily roll across the wet ring.

To Blacken Brass. — 1. Nitrate of silver, 120 grains; water, 5 ounces.

2. Nitrate of copper, 120 grains; water, 5 ounces.

Mix in equal quantities sufficient of the above to cover the metal to be blackened. Dip it in the solution, then heat in an oven until black as desired. The brass must be free from all grease before dipping. It can be cleaned of all grease by dipping it into hot soda water.

Thawing frozen Pipes with Lime. — Pack unslaked lime around the pipe, wrap with old rags or carpet and pour water over the lime; the heat generated by the slaking of the lime will thaw the pipe.

White Metal. — The formula for white metal is tin, 42 parts; lead, 40 parts; antimony, 20 parts, and cupromanganese, 2 parts. The metals should be melted rapidly to prevent loss and stirred constantly, then covered with a layer of charcoal to prevent oxidation.

To Keep Machinery from Rusting. — Take one ounce of camphor, dissolve it in one pound of melted lard; take off the scum, and mix in it as much fine, black lead as will give it an iron

color. Clean the machinery and coat it with this paste. After standing for about twenty-four hours, clean it off with a soft cloth. It will keep clean without rusting for several months.

Length of Service of Electric Lamps. — Electric lamps should not be burned more than 800 hours; while they will often last longer than this length of time, they will grow dim, not giving as much light as they should but at the same time using as much electric current as a good lamp.

To Cut a Glass Gauge Tube. — Score it on one side with the corner of a file; then hold in both hands with the thumb back of the mark and using the thumbs as fulcrums, break the tube, which will break at the point cut with the file.

To Cut a Glass Jar or Bottle. — (1) Fill the jar or bottle with lard oil to the point where it is desired to cut it, then heat a piece of iron to a high temperature and dip in the oil. This will start the oil boiling and the sudden change of temperature will usually cause the glass to break evenly all around at the surface of the oil.

(2) Turn an eye, large enough to take the size of the bottles you wish to break, on one end of a ½-in. iron rod and leave a handle about 2½ ft. long. Put the tool in the fire and heat to a shade over red, says a correspondent of the "Blacksmith and Wheelwright." Put the hot eye of the tool over the bottle to the point where you wish it cut; turn the bottle around a few times, then take it out of the eye and dip it in cold water, and the cut will be just where you intended.

To Freeze a Water Pipe. — Take a box and cut a slot in each end so the box can be brought up under the pipe with the pipe in the two slots. Fill the box with chipped ice and salt, or pour ammonia over the ice.

To Make a Rust Joint. — Mix 10 parts of iron filings and 3 parts of chloride of lime to a paste with water. Apply to the joint and clamp up; it will be solid in twelve hours.

To Make a Rust Joint (for quick setting).— Sal-ammoniac powdered, 1 lb.; flower of sulphur, 2 lbs.; iron borings, 80 lbs.; mix to a paste with water.

To Make a Rust Joint (for slow setting). — Sal-ammoniac, 2 lbs.; sulphur, 1 lb.; iron borings, 200 lbs.; this makes the strongest joint if time can be given for it to harden.

To Remove Rust from Steel. — Brush the rusted steel with a paste composed of ½ oz. cyanide potassium, ½ oz. castile soap,

1 oz. whiting and enough water to form a paste. Then wash the steel in a solution of ½ oz. cyanite of potassium in 2 oz. water.

A Solvent for Rust. — It is often very difficult and sometimes impossible to remove rust from articles made of iron. Those which are most thickly coated are most easily cleaned by being immersed in a solution, nearly saturated, of chloride of tin. The length of time they remain in this bath is determined by the thickness of the coating of rust. Generally twelve to twenty-four hours is long enough. The solution ought not to contain a great excess of acid, if the iron itself be not attacked. On taking them from the bath the articles are rinsed, first in water, then in ammonia, and quickly dried. The iron, when thus treated, has the appearance of dull silver. A simple polishing gives it its normal appearance.

To Brighten Tarnished Brass and Copper. — Clean the metal by warming it and dipping it in water charged with washing soda; then dip it in clear water to remove the grease. Next dip it into a bath of one part, by measure, of sulphuric acid, one part sal-ammoniac, two parts nitric acid, and four parts water.

Dip for a moment, then dip in clear water and dry in warm sawdust.

Oxalic acid dissolved in soft water in proportion of one-half ounce acid to a pint of water is also a good wash for brightening brass work.

Substitute for Fire Clay. — A good substitute for fire clay for repairing fireplaces, etc., is common clay mixed with water to which a little salt has been added.

Whitewash. — Common whitewash is made by slaking fresh lime and adding enough water to make a thin paste; by using 2 pounds of sulphate of zinc and 1 pound of salt to each half bushel of lime the whitewash will be much harder and not crack. A half pint of linseed oil to each gallon of whitewash will make it more durable for outside work. To color, add to each bushel of lime 4 to 6 pounds of ochre for cream color, 6 to 8 pounds amber, 2 pounds Indian red, and 2 pounds of lampblack for fawn color; 6 to 8 pounds raw umber and 3 or 4 pounds lampblack for buff or stone color.

To Make Iron Take a Bright Polish like Steel.— Pulverize and dissolve the following articles in 1 qt. hot water; blue vitriol, 1 oz.; borax, 1 oz.; prussiate of potash, 1 oz.; charcoal, 1 oz.; salt, ½ pt.; then add 1 gal. linseed oil; mix well; bring your iron

or steel to the proper heat and cool in the solution. It is said the manufacturers of the Judson governor paid $100 for this receipt, the object being to case-harden iron, so that it would take a bright polish like steel.

To Make Lead Joints under Water. — Use lead wool which consists of small fibers of lead, which when calked forms a solid joint.

To Clean Porcelain Fixtures. — To clean porcelain fixtures use hot water and a rag saturated with gasoline or coal oil; or smear a little vaseline on the dirtiest places and scour with a rag and hot water.

To Find the Diameter of Pump Cylinder. — To find the diameter of a pump cylinder to move a given quantity of water per minute, divide the number of gallons by 4, then extract the square root, and the product will be the diameter in inches of a pump cylinder required to do the work at a piston travel of 100 feet per minute.

Insulating Paste. — Take linseed oil, 2 parts; cottonseed oil, 1 part; heavy petroleum, 2 parts; light coal tar, 2 parts; Venice turpentine, $\frac{1}{2}$ part; spirits of turpentine, 1 part; gutta-percha, $\frac{1}{6}$ part; sulphur, 2 parts; heat the oils separately to about 300° F.; cool to 240 degrees, and mix in the other materials, the sulphur last. After the materials have been mixed together heat to 300° F. for about an hour or until the mixture becomes pasty, and on cooling is soft and elastic.

To Extinguish Chimney Fires. — A burning chimney, when the soot has been lighted from the fire in the grate, can be extinguished by shutting all the doors and windows of the room, to prevent a current of air up the chimney; then, by throwing a few handfuls of salt on the fire, the fire in the chimney will be extinguished. The salt in burning produces muriatic acid gas which extinguishes the fire.

To Loosen Clinkers. — Put oyster shells, one at a time, in the fire when the fire is burning brightly, and the clinkers will loosen from the sides of the fire bricks.

How to Use the Hack-saw. — Strain the blade well in the frame and run slowly, not to exceed fifty strokes per minute. Bear hard on the forward stroke so that the blade will not slip, and ease up on the backward or return stroke. Do not bend the frame sidewise. When putting the blade in the frame see that the rake of the teeth is forward.

To Use the Power Hack-saw. — Strain the blade well in the frame, with the rake of the teeth forward. See that the guide is properly adjusted, and run slowly, not to exceed fifty strokes per minute. Always start the saw on the backward stroke as the teeth are not so liable to strip or the saw break as when started on the forward stroke.

Soldering a Ball Water Float. — When soldering a leak in a ball water float, partly immerse it in cold water to take up the heat from the soldering iron; otherwise the heat may expand the air in the ball and cause another leak.

Increasing the Heating Power of Coal. — Coal burns much better if it is wet when put on the fire, and still better results are obtained if a couple of handfuls of salt has been dissolved in each bucket of water used to wet the coal.

The coal can be wet with a salt solution once or twice a week, and the solution will dry on the coal, leaving a deposit of salt on the surface of the coal, which will make it burn better and hotter.

To Fasten Tools in their Handles. — To fasten steel tools in their handles, put some powdered rosin and rotten stone in the hole of the handle. Heat the tang of the tool hot enough to melt the rosin and push it firmly down into the handle; when it is cold it will be firmly set.

To Fix Pencil Marks so they will not Rub out — Take well skimmed milk and dilute with an equal bulk of water. Wash the pencil marks (whether writing or drawing) with this liquid, using a soft camel-hair brush, and avoid any rubbing. Place on a flat board to dry.

Stove Cleaning Liquid. —An excellent stove cleaner and polish is made by dissolving 2 ounces of beeswax in 1 quart of gasoline and then add $\frac{1}{4}$ pint of turpentine. Shake well before using, and never use near a light or fire.

To Color Electric Lamps. — To color electric lamps for decorative purposes, take a little white shellac and cut it with alcohol; dip the lamp in this mixture and let dry, when it produces a good imitation of frosted or ground glass.

For coloring take a little egg dye of the color desired and dissolve it in a little alcohol and color the shellac with this coloring. When desired the lamps can be cleaned with alcohol. Another method is to dip the lamps in, or paint them with a solution of collodion, in which an aniline dye of the desired color has been

dissolved. These dyes can be obtained at any drug store, and are about the same as the egg dyes.

When dipping the lamps be careful not to wet the base of the lamp.

Toilet Paper Reel. — The reel for toilet paper in public lavatories should be such that the roll of paper cannot be taken off except by unrolling it.

To Keep Plaster of Paris from Setting Quickly. — To retard the setting of plaster of paris, mix with diluted vinegar. Mixed with pure vinegar it will not set for about six hours. For ordinary use as filling cracks, etc., mix with a solution of 3 parts water and 1 part vinegar.

To Take Rust Spots Off Marble. — To remove rust spots from marble, apply a mixture of 1 part nitric acid and 25 parts water, then rinse off with 3 parts water and 1 part ammonia.

Etching on Metals. — Etching on metals can be done with a rubber stamp as follows: With a stamp of the desired design or words use asphaltum varnish in place of ink and stamp the design on the metal. When the varnish has dried apply acids as follows, which will eat into the metal at the exposed places leaving the design in relief.

Etching. — The following acids for etching will give good results. *Iron and Soft Steel.* — Nitric acid, 1 part; water, 4 parts.

Hard Steel. — Nitric acid, 2 parts; acetic acid, 1 part.

Deep Etching. — Hydrochloric acid, 10 parts; chlorate of potash, 2 parts; water, 88 parts.

Etching Bronze. — Nitric acid, 100 parts; muriatic acid, 5 parts.

Brass. — Nitric acid, 16 parts; water, 160 parts. Dissolve 6 parts potassium chlorate in 100 parts of water, then mix the two solutions and apply.

Hammering in Boilers, Pipes, etc. — Hammering or snapping in a range boiler or hot water pipes is caused from the sagging of the pipes causing traps in the system or from stoppage in the water-back. Hammering in pipes when water is being drawn may be caused by a loose part of one of the faucets or cocks, or by a large leather washer, the leather overhanging the seat, and vibrating, thus causing the noise. In a heating system it may be caused by air at some point in the pipe and an air valve placed at this point will remedy the trouble.

To Prevent Siphonage of Hot Water Boiler. — To prevent siphonage of the hot water boiler and water-back, drill a small hole in the cold water supply pipe inside the boiler at a point just above the line of the water-back. When the water is then drawn down to this point it will take air and stop the siphonage.

Location of Basin Cocks. — On wash basins, bath tubs, etc., the hot water cock should be placed on the left hand side, and the cold water on the right.

Connecting up Water–Backs. — Never connect a water-back directly to the city supply; always take the supply for the water-back from the bottom of the boiler.

Bronzing Liquid. — A liquid for mixing bronze for use on heating pipes, etc., is made by mixing one part of clear baking varnish with from two to three parts of turpentine.

Bronzing Pipes, Radiators, etc. — Size the surface to be bronzed with a good slow drying baking varnish cut with about one-half turpentine, after the sizing becomes dry enough to be "tacky" rub on the bronze with a soft rag or brush.

This will give a much brighter finish than any of the liquid paints. Aluminum bronze is put on the same way.

To Build up Threads of Fittings. — Oftentimes it is found that the threads of brass fittings are cut a little large for the pipe they are to be put on and it is hard to get the fitting tight. To remedy this cover the thread with acid or powdered paraffine and dip the exposed threads in the soldering pot, or with the iron give the threads a coat of solder. By this method the threads can be built up enough to take up considerable "play."

Lead Wool. — Lead wool is a material recently invented for the joints of gas and water mains. It consists of fine threads cut from pure lead, and is sold in strands about three feet long. Opium is put in the joint in the usual manner and then instead of pouring in hot lead the wool is calked in without heating. Each turn of the wool around the pipe should be well calked before another one is inserted.

To Clean the Hands of Tar. — Rub the hands with the outside of fresh orange or lemon peel, and wipe dry. The volatile oil in the peel dissolves the tar so it can be wiped off.

To Clean Gas Fixtures. — Gas fixtures that have become clogged with dirt can be cleaned by attaching the fixtures to a steam pipe and letting the steam go through the pipe under considerable pressure. This will take out all the dirt.

Making Fittings. — To make a reducing fitting, screw a coupling on to a nipple and cut a thread on the outside of the coupling. The same practice can be done with an elbow or tee by cutting a thread on the outside.

To Use Hot Water Radiators for Steam. — When it is desired to use hot water radiators for steam, all that is necessary is to change the location of the air valve to a point about one-third the height of the radiator. The only thing that may cause trouble is that it is sometimes difficult to get the air out of a hot water radiator when it is being used for steam.

Painting Galvanized Iron with Aluminum. — After the metal has stood to the weather for several weeks, give two coats of red lead and linseed oil, after which give a coat of aluminum bronze, which will give a silver finish. Or if the metal is to be painted immediately after being put in place, wash it with one of the washes given under "Making Paint Adhere to Galvanized Iron."

Making Paint Adhere to Galvanized Iron. — (1) Apply a solution of ammonia water, using a whitewash brush to put it on with. Allow this to dry before applying the paint, and there will be no difficulty about the paint sticking to the iron.

(2) Wash the surface with a delicate mixture of muriatic acid, vinegar and water. Let it stand for 24 hours and then wash with cold water. It is then ready for paint.

(3) Dissolve 2 ounces of copper chloride, 2 ounces of copper nitrate, 2 ounces sal-ammoniac, in one gallon of clear soft water, and when the solution is complete add 2 ounces of crude hydrochloric acid, and apply with a brush.

The acid solutions should be prepared in a glass or earthenware vessel, and in applying the solution should not be allowed to get into the joints where it will come in contact with the edge of the iron which is not plated and cause rust.

To Fasten Linoleum to Cement Floors. — To make linoleum adhere to a cement floor use a cement made by adding sifted wood ashes to glue, making a mixture of about the consistency of varnish; apply to the lower side of the linoleum and press hard against the floor.

To Clean Grease out of Waste Pipes. — When the waste pipe from sinks, etc., becomes stopped up with grease, run sal-soda or lye into the pipe which will eat away the grease so it will wash out.

To Polish Lead Pipes. — To polish old lead pipe, rub it with fine sand paper which will give it a bright finish. The sand paper should be rubbed lengthwise of the pipe. Or rubbing the pipe with a piece of old carpet will give the pipe a dull finish. After polishing, the pipe should be given a coat of shellac.

Heating Value of Crude Oil. — Tests have been made in California to determine the relative heating value of crude oil and local coal. It was found that one net ton of coal was equivalent to 718 pounds, or 94.5 gallons of oil.

Lead against Oak Wood. — Do not use lead in contact with oak wood, unless the oak is perfectly dry. The gallic or acetic acid in the wood will turn the lead into acetate of lead or ceruse.

To Install a Hot Water Boiler below the Water-back. — When it is necessary to place the hot water boiler below the range or water-back, carry the flow pipe vertical as high as convenient to form a loop and insure circulation. A good rule is: Carry the flow vertical as many feet as it is desired to drop below the water-back in inches; at the top of the loop formed by the flow pipe, place an air cock to prevent the pipe from becoming air-bound.

Setting Urinals. — When urinals set against and are connected through a marble slab, the marble should be kept far enough away from the wall to give space for the pipes and fittings; then there should be a hole cut through the marble back of the urinal, large enough so a person can reach in behind the marble to unscrew the connections. In this way the urinal can be taken down and the connections broken without taking down the marble.

To Solder Lead to Brass. — Tin the brass using tallow as a flux; then using a muriatic acid flux solder the brass and lead together.

Use of Wrench or Tongs on Valves. — When screwing on a valve always use the wrench or tongs on the end of the valve being screwed on the pipe; if the wrench is used on the hexagon farthest from the pipe the body of the valve receives all the twist and strain and which is liable to twist the body of the valve and spring the seat, causing a leaky valve. Always close valves tight before screwing them on to pipe or screwing pipe into them, as this makes the body of the valve more rigid and not so liable to be twisted or sprung.

MENSURATION TABLES, ETC.

LINEAR MEASURE.

1 hair's breadth	=	$\frac{1}{48}$ inch.
3 barleycorns (lengthwise)	=	1 inch.
7.92 inches	=	1 link.
12 inches	=	1 foot = 0.3048 metre.
3 feet	=	1 yard = 0.91438 metre.
$5\frac{1}{2}$ yards	=	1 rod, perch, or pole.
4 poles or 100 links	=	1 chain.
10 chains	=	1 furlong.
8 furlongs	=	1 mile = 1.6093 kilometres = 5280 ft.
3 miles (nautical)	=	1 league.
1 line	=	$\frac{1}{12}$ inch.
1 nail (cloth measure)	=	$2\frac{1}{4}$ inches.
1 palm	=	3 inches.
1 hand (used for height of horses)	=	4 inches.
1 span	=	9 inches.
1 cubit	=	18 inches.
1 pace (military)	=	$2\frac{1}{2}$ feet.
1 pace (common)	=	3 feet.
1 Scotch ell	=	37.06 inches.
1 vara (Spanish)	=	33.3 inches.
1 English ell	=	45 inches.
1 fathom	=	6 feet.
1 cable's length	=	120 fathoms.
1 "knot"	=	6082.66 feet.
1 degree of equator	=	69.1613 statute miles.
1 degree of meridian	=	69.046 statute miles
1 degree of equator	=	60 geographical miles.
1 degree of meridian	=	59.899 geographical miles.
1.1527 statute miles	=	1 geographical mile.
6086.07 feet	=	1 minute of longitude = 1 nautical mile.

SQUARE OR SURFACE MEASURE.

144 square inches	=	1 square foot.
9 square feet	=	1 square yard = 1296 square inches.
100 square feet	=	1square (builders' measure).

LAND MEASURE.

$30\frac{1}{4}$ square yards........	=1 square rod.
40 square rods.........	=1 square rood = 1210 square yards.
4 square roods........	=1 acre = 4840 square yards.
640 acres...............	=1 square mile.
208.71 feet square.......	=1 acre.
1 square mile..........	=1 section of land.
160 acres...............	$=\frac{1}{4}$ section of land.

CUBIC MEASURE.

1728 cubic inches...........	=1 cubic foot.
27 cubic feet..............	=1 cubic yard.
128 cubic feet..............	=1 cord.
40 cubic feet..............	=1 American shipping ton.
42 cubic feet..............	=1 British shipping ton.
108 cubic feet..............	=1 stack of wood.
24.75 cubic feet of stone......	=1 perch.

Note.—In Oklahoma, North Dakota, South Dakota, and Ohio a perch is fixed at 25 cu. ft. of stone. In Delaware it is $24\frac{3}{4}$ cu. ft. in walls, 27 cu. ft. when piled on the ground, 30 cu. ft. when in a boat, and $30\frac{1}{2}$ cu. ft. in cars. In Colorado a perch of stone in mason work is $16\frac{1}{2}$ cu. ft., and for brickwork measure laid in a wall, 22 bricks per cubic foot for a foot wall and 15 bricks for what is known as an 8-inch wall. In Philadelphia 22 cu. ft. is considered a perch.

AVOIRDUPOIS WEIGHT (ORDINARY COMMERCIAL WEIGHT).

16 drams........... =	1 ounce, oz.
16 ounces........... =	1 pound, lb.
28 lbs. (old)......... =	1 quarter, qr.
4 quarters (old) / 100 lbs., pounds .. =	1 hundredweight.
20 hundredweight ... =	1 ton.
100 pounds.......... =	1 cental.
175 troy pounds...... =	144 avoirdupois.
1 troy pound....... =	5760 grains.
1 avoirdupois pound =	7000 grains.

Avoirdupois weight is used to weigh all coarse articles, as hay, meat, fish, potash, groceries, flax, butter, cheese, etc., and metals, except precious metals. Formerly the usual custom was to allow 112 pounds for a hundredweight and 28 pounds for a

quarter, but this practice has very nearly passed away. The custom-house still adheres to the old usage.

APOTHECARIES' MEASURE—LIQUID.

60 minims or drops, m.,	=1 fluid drachm.
8 fluid drachms.	=1 fluid ounce.
16 fluid ounces	=1 pint (octarius).
8 pints.	=1 gallon (congius).

These apothecaries' weights and measures are used by apothecaries and physicians in compounding medicines, but drugs and medicines are bought and sold by avoirdupois weight.

The standard avoirdupois pound is the weight of 27.7015 cubic inches of distilled water weighed in air at 39.1°, the barometer at 30 inches.

APOTHECARIES' WEIGHT—DRY.

20 grains. .	=1 scruple.
3 scruples	=1 dram.
8 drams. .	=1 ounce.
12 ounces	=1 pound.

LIQUID OR WINE MEASURE.

4 gills.	=1 pint, pt.
2 pints.	=1 quart, qt.
4 quarts	=1 gallon, gal.
42 gallons.	=1 tierce.
1½ tierces or 63 gallons. . . .	=1 hogshead, hhd.
84 gallons.	=1 puncheon.
1½ puncheons or 126 gallons	=1 pipe.
2 pipes.	=1 tun.
231 cubic inches.	=1 gallon.
10 gallons.	=1 anker.
18 "	=1 runlet.
31½ "	=1 barrel.

This measure is used to measure water, wine, spirits, cider, oil, honey, etc. In London the gill is usually called a quartern.

ALE OR BEER MEASURE.

2	pints.....	=1 quart.
4	quarts....	=1 gallon.
9	gallons....	=1 firkin.
2	firkins....	=1 kilderkin.
2	kilderkins	=1 barrel.
$1\frac{1}{2}$	barrels....	=1 hogshead.
$1\frac{1}{3}$	hogsheads	=1 puncheon.
$1\frac{1}{2}$	puncheons	=1 butt.

Used to measure beer, ales, porter, etc. An ale gallon measures 282 cubic inches.

ENGLISH WINE MEASURE.

18	U. S. gallons....	=1 runlet.
25	English gallons	=1 tierce.
42	U. S. gallons	
$7\frac{1}{2}$	English gallons..	=1 firkin of beer.
4	firkins..........	=1 barrel.
$52\frac{1}{4}$	English gallons	=1 hogshead.
63	U. S. gallons	

DRY MEASURE.

2 pints...	=1 quart ..	=	67.2	cubic inches.
4 quarts.	=1 gallon ..	=	268.8	" "
2 gallons.	=1 peck....	=	537.6	" "
4 pecks..	=1 bushel..	=	2150.42	" "
36 bushels	=1 chaldron	=	57.244	" feet.
4 bushels (in England)	=1 coon.			
2 coons " "	=1 quarter.			
5 quarters " "	=1 wey.			
2 weys " "	=1 last.			

A gallon, dry measure, measures $268\frac{4}{5}$ cubic inches.
" " liquid " " 231 " "

SURVEYORS' SQUARE MEASURE.

625	square links	=1 square rod, sq. rd.
16	" rods	=1 " chain, sq. ch.
10	" chains	=1 acre, A.
640	acres	=1 square mile, sq. mi.
36	square miles or 6 miles square	= 1 township, tp.

SURVEYORS' LONG MEASURE.

7.92 inches . .	=1 link.
25 links. . . .	=1 pole.
100 links. . . .	=1 chain.
10 chains. .	=1 furlong.
8 furlongs	=1 mile.

Used by surveyors, civil engineers, etc., in measuring distances.

MEASURE OF TIME.

60 seconds, sec.	=1 minute, min.
60 minutes.	=1 hour, hr.
24 hours.	=1 day, dy
7 days.	=1 week, wk.
2 weeks.	=1 fortnight.
4 weeks.	=1 month, mo.
13 months 1 day 6 hrs.	=1 Julian year.
365 days 6 hours.	=1 Julian year.
366 days.	=1 leap year.
12 calendar months. .	=1 year.

Used for computing time.

CIRCULAR MEASURE.

60 seconds, ″. .	=1 minute, ′.
60 minutes. . . .	=1 degree, °.
30 degrees. . . .	=1 sign, s.
90 degrees. . . .	=1 quadrant.
12 signs	=a circle.
4 quadrants / 360 degrees . .	=a circumference of a circle.

Used in measuring latitude, longitude, etc.

TROY WEIGHT.

Used in Weighing Gold or Silver.

24 grains.	=1 pennyweight.
20 pennyweights	=1 ounce.
12 ounces.	=1 pound.

A carat of the jewellers, for precious stones, is, in the United States, 3.2 grains; in London, 3.17 grains; in Paris 3.18 grains are divided into 4 jewellers' grains. In troy, apothecaries', and avoirdupois weights the grain is the same.

MEASURES OF VALUE.

U. S. Standard.

10 mills. . = 1 cent.
10 cents. . = 1 dime.
10 dimes = 1 dollar.
10 dollars = 1 eagle.

The standard of gold and silver is 900 parts of pure metal and 100 parts of alloy to 1000 parts of coin.

WEIGHT OF COIN.

Double eagle.	=516 troy grains.
Eagle.	=258 troy grains.
Dollar (gold).	= 25.8 troy grains.
Dollar (silver).	=412.5 troy grains.
Half dollar.	=192 troy grains.
5-cent piece (nickel)	= 77.16 troy grains.
3-cent piece (nickel)	= 30 troy grains.
Cent (copper).	= 48 troy grains.

NUMBER OF ENGLISH OR UNITED STATES YARDS IN MILES OF DIFFERENT NATIONS.

Name.	Yards.	Name.	Yards.
Arabian	2,148	Luthenian	9,784
Bohemian	10,187	Oldenburg	10,820
Brebant	6,082	Persian (paisang)	6,082
Burgundy	6,183	Polish (long)	8,101
Chinese (Hls)	682	Polish (short)	6,095
Dutch (Ure)	6,395	Portuguese (leguos)	6,760
Danish	8,244	Prussian	8,498
English (U. S.)	1,760	Roman (modern)	2,035
English (geographical)	2,025	Roman (ancient)	1,613
Flemish	6,869	Russian (verst)	1,167
German (geographical)	8,100	Saxon	9,905
Hamburg	8,244	Scotch	1,984
Hanover	11,559	Silesian	7,083
Hesse	10,547	Spanish (leguas)	4,630
Hungarian	9,113	Spanish (com.)	7,416
French (art leagues)	4,860	Swiss	9,166
French (marine)	6,075	Swedish	11,704
Legal Le'g'e (2000 toises)	4,263	Turkey	1,821
Irish	3,338	Tuscan	1,808
Italian	2,025	Vienna (post mile)	8,296

TABLE OF MISCELLANEOUS WEIGHTS.

14 pounds.	=1 stone (horseman's weight).
56 pounds.	=1 firkin of butter.
64 pounds.	=1 firkin of soft soap.
112 pounds.	=1 barrel of raisins.
256 pounds.	=1 pack of soft soap.
196 pounds.	=1 barrel of flour.
200 pounds.	=1 barrel of beef, pork, or fish.
280 pounds.	=1 barrel of salt, New York.
22 stones (301 lbs.).	=1 sack of wool.
17 stones 2 lbs. (240 lbs.)	=1 pack of wool.
60 pounds.	=1 truss of hay (new).
50 pounds.	=1 truss of hay (old).
40 pounds.	=1 truss of straw.
400 pounds.	=1 bale of cotton.
100 pounds.	=1 quintal of fish.

COMMON WEIGHTS AND MEASURES AND THEIR METRIC EQUIVALENTS.

An inch = 2.54 centimetres.
A foot = .3048 metre.
A yard = .9144 metre.
A rod = 5.029 metres.
A mile = 1.6093 kilometres.
A square inch = 6.452 square centimetres.
A square foot = .0929 sq. m.
A square yard = .8361 sq. m.
An acre = .4047 hectare.
A square mile = 259 hectares.
A cubic foot = .02832 cu. m.
A cubic yard = .7646 cu. m.
A cord = 3.624 steres.

A liquid quart = .9465 litre.
A gallon = 3.786 litres.
A dry quart = 1.101 litres
A peck = 8.811 litres.
A bushel = 35.24 litres.
An ounce avoirdupois = 28.35 grams.
A pound avoirdupois = .4336 kilogram.
A ton = .9072 tonneau.
A grain troy = .0648 gram.
An ounce troy = 31.104 grms.
A pound troy = .3732 kgrm.

U. S. Land Measure.

A range is a line of townships running north and south, and is known by its number east or west of the principal meridian.

A township is divided into 36 equal squares, called sections, each 1 mile square, and containing 640 acres.

A section is variously divided for purposes of sale. The U. S. Land Office recognizes the following divisions:

Half-section.	$=1\times\frac{1}{2}$ mile	$=\frac{1}{2}$ sq. mile	$=320$ acres
Quarter-section.	$=\frac{1}{2}\times\frac{1}{2}$ mile	$=\frac{1}{4}$ sq. mile	$=160$ acres
Half-quarter-section	$=\frac{1}{2}\times\frac{1}{4}$ mile	$=\frac{1}{8}$ sq. mile	$=80$ acres
Quarter-quarter-section. . . .	$=\frac{1}{4}\times\frac{1}{4}$ mile	$=\frac{1}{16}$ sq. mile	$=40$ acres

Old French Linear and Land Measure.

12 lines.	=1 inch	6 feet.	=1 toise
12 inches.	=1 foot	32 toises.	=1 arpent

1024 sq. toises. . . . . . =1 sq. arpent

The French foot equals 12.79 English inches.

The arpent is the old French name for acre, and contains nearly $\frac{5}{6}$ of an English acre.

SPANISH LAND MEASURE.

Sometimes used in Texas, Mexico New Mexico, Arizona, and California.

26,000,000	sq. varas (sq. of 5099	varas) = { 1 league 1 labor	=4605.5	acres.
1,000,000	sq. varas (sq. of 1000	varas) = 1 labor	= 177.136	acres.
25,000,000	sq. varas (sq. of 5000	varas) = 1 league	=4428.4	acres.
12,500,000	sq. varas (sq of 3535.5	varas) = $\frac{1}{2}$ league	=2214.2	acres.
8,333,333	sq. varas (sq. of 2886.7	varas) = $\frac{1}{3}$ league	=1476.13	acres.
6,250,000	sq. varas (sq. of 2500	varas) = $\frac{1}{4}$ league	=1107.1	acres.
7,225,600	sq. varas (sq. of 2688	varas)	=1280	acres.
3,612,800	sq. varas (sq. of 1900.8	varas) = 1 section	= 640	acres.
1,806,400	sq. varas (sq. of 1344	varas) = $\frac{1}{2}$ section	= 320	acres.
903,200	sq. varas (sq. of 950.44	varas) = $\frac{1}{4}$ section	= 160	acres.
451,600	sq. varas (sq. of 672	varas) = $\frac{1}{8}$ section	= 80	acres.
225,800	sq. varas (sq. of 475	varas) = $\frac{1}{16}$ section	= 40	acres.
5,645.376	sq. varas (sq. of 75.137	varas) = 4840 sq. yd.	= 1	acre.

To find the number of acres in any number of square varas multiply the latter by 177 (or to be more exact, by 177$\frac{1}{8}$), and cut off six decimals.

1 vara = 33$\frac{1}{3}$ inches. 1900.8 varas = 1 mile.

WEIGHTS AND MEASURES OF THE PHILIPPINES.

1 polgrada (12 linea)	=	.927	inch
1 pie	=	11.125	inches
1 vara	=	33.375	inches
1 gantah	=	.8796	gallon
1 caban	=	21.991	gallons
1 libra (16 onzo)	=	1.0144	lb. av.
1 arroba	=	25.360	lb. av.
1 catty (16 tael)	=	1.94	lb. av.
1 pecul (100 catty)	=	139.482	lb. av.

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL OF VARIOUS COMMODITIES PREPARED BY DEPARTMENT OF COMMERCE AND LABOR, BUREAU OF STANDARDS, WASHINGTON.

The list below includes products for which legal weights have been fixed in but one or two States.

Apple seeds, 40 pounds (Rhode Island and Tennessee).
Beggarweed seed, 62 pounds (Florida).
Blackberries, 32 pounds (Iowa); 48 pounds (Tennessee); dried, 28 pounds (Tennessee).
Blueberries, 42 pounds (Minnesota).
Bromus inermus, 14 pounds (North Dakota).
Cabbage, 50 pounds (Tennessee).
Canary seed, 60 pounds (Tennessee).
Cantaloupe melon, 50 pounds (Tennessee).
Cement, 80 pounds (Tennessee).
Cherries, 40 pounds (Iowa); with stems, 56 pounds (Tennessee); without stems, 64 pounds (Tennessee).
Chestnuts, 50 pounds (Tennessee); 57 pounds (Virginia).
Chufa, 54 pounds (Florida).
Cottonseed, staple, 42 pounds (South Carolina).
Cucumbers, 48 pounds (Missouri and Tennessee); 50 pounds (Wisconsin).
Currants, 40 pounds (Iowa and Minnesota).
Feed, 50 pounds (Massachusetts).
Grapes, 40 pounds (Iowa); with stems, 48 pounds (Tennessee); without stems, 60 pounds (Tennessee).
Guavas, 54 pounds (Florida).
Hickory nuts, 50 pounds (Tennessee).

Hominy, 60 pounds (Ohio); 62 pounds (Tennessee).
Horseradish, 50 pounds (Tennessee).
Italian rye-grass seed, 20 pounds (Tennessee).
Johnson grass, 28 pounds (Arkansas).
Kaffir corn, 56 pounds (Kansas).
Kale, 30 pounds (Tennessee).
Land plaster, 100 pounds (Tennessee).
Meal, 46 pounds (Alabama); unbolted, 48 pounds (Alabama).
Middlings, fine, 40 pounds (Indiana); coarse middlings, 30 pounds (Indiana).
Millet, Japanese barnyard, 35 pounds (Massachusetts).
Mustard, 30 pounds (Tennessee).
Plums, 40 pounds (Florida); 64 pounds (Tennessee).
Plums, dried, 28 pounds (Michigan).
Popcorn, 70 pounds (Indiana and Tennessee); in the ear, 42 pounds (Ohio).
Prunes, dried, 28 pounds (Idaho); green, 45 pounds (Idaho).
Quinces, 48 pounds (Florida, Iowa, and Tennessee).
Rape-seed, 50 pounds (Wisconsin).
Raspberries, 32 pounds (Kansas); 48 pounds (Tennessee).
Rhubarb, 50 pounds (Tennessee).
Sage, 4 pounds (Tennessee).
Salads, 30 pounds (Tennessee).
Sand, 130 pounds (Iowa).
Spelt or spiltz, 40 pounds (North Dakota); 45 pounds (South Dakota).
Spinach, 30 pounds (Tennessee).
Strawberries, 32 pounds (Iowa); 48 pounds (Tennessee).
Sugar-cane seed, 57 pounds (New Jersey.)
Velvet-grass seed, 7 pounds (Tennessee).
Walnuts, 50 pounds (Tennessee).

On the pages following are tabulated the products for which legal weights have been more widely established.

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL.

	Apples.			Beans.								
	Apples.*	Dried Apples.	Barley.	Beans.*	Castor Beans (shelled).	Beets.	Blue-grass Seed.	Bran.*	Broom-corn Seed.	Buckwheat.	Carrots.	Charcoal.
U. S.	....	....	48	....	50	....	....	....	....	42	....	....
Alabama.	....	24	47	60	....	....	....	....	....	....	....	....
Arizona.	....	....	45	*a*55	....	....	....	....	....	....	....	....
Arkansas.	*b* 50	24	48	*a*60	....	....	14	20	48	52	....	....
California.	....	....	50	....	....	....	....	....	....	40	....	....
Colorado.	....	....	48	60	....	....	14	....	....	52	....	....
Conn.	48	25	48	60	....	*c* 60	....	20	....	48	50	20
Delaware.	....	....	....	....	....	....	....	....	....	....	....	20
Florida.	*b* 48	24	48	*d*60	48	....	....	20	....	....	....	....
Georgia.	....	24	47	*e* 60	....	....	14	*f* 20	....	52	....	....
Hawaii.	....	....	48	....	....	....	....	....	....	....	....	....
Idaho.	*b* 45	28	48	....	....	....	....	....	....	42	....	....
Illinois.	....	24	48	*e* 60	46	....	14	20	....	52	....	....
Indiana.	....	25	48	60	46	....	14	....	....	50	....	....
Iowa.	48	24	48	60	46	....	14	20	30	52	....	20
Kansas.	*b* 48	24	48	60	46	....	*g*14	20	....	50	....	....
Kentucky	....	24	47	*e* 60	*45	....	14	20	....	56	....	....
Louisiana.	....	....	48	....	....	....	....	....	....	....	....	....
Maine.	44	....	48	60	....	60	....	....	....	48	50	....
Maryland	....	....	....	....	....	....	....	....	....	....	....	20
Mass.	48	25	48	*h* 60	....	....	....	20	....	48	50	....
Michigan.	48	22	48	60	46	....	14	....	....	48	....	....
Minnesota	*b* 50	28	48	60	....	50	14	....	57	50	45	20
Mississippi	....	26	48	*e* 60	46	....	14	20	....	48	....	....
Missouri.	48	24	48	*i* 60	46	....	14	20	....	52	50	....
Montana.	45	....	48	60	....	50	14	20	....	52	50	....
Nebraska	....	24	48	*e* 60	46	....	14	20	....	52	....	....
New Ham.	....	....	....	62	....	....	....	....	....	....	....	....
N. Jersey.	50	25	48	60	....	....	....	....	....	50	....	....
New York	48	25	48	60	....	....	....	20	....	48	50	....
N. Car.	....	....	48	....	....	....	....	....	....	50	....	....
N. Dakota	50	....	48	60	....	60	....	20	30	42	....	....
Ohio.	50	24	48	60	....	56	....	....	....	50	50	....
Oklahoma	....	....	48	60	....	60	....	20	30	42	....	....
Oregon.	45	28	46	....	....	....	....	....	....	42	....	....
Penn.	....	....	47	....	....	....	....	....	....	48	....	*jk*18
R. Island.	48	25	48	60	46	50	....	20	....	48	50	20
S. Dakota	....	....	48	60	....	60	....	20	30	42	....	....
Tennessee	*b* 50	24	48	*il* 60	46	50	14	20	42	50	50	22
Texas.	45	28	48	*e* 60	....	....	....	20	....	42	....	22
Vermont.	46	....	48	62	....	60	....	....	....	48	50	....
Virginia.	....	28	48	*e* 60	....	....	14	....	....	52	....	....
Wash.	*b* 45	28	48	....	....	....	....	....	....	42	....	....
W. Va.	....	25	48	60	....	....	....	....	....	52	....	....
Wisconsin	50	25	48	60	....	50	....	20	....	50	50	....

* Not defined.

a Small white beans, 60 pounds.
b Green apples.
c Sugar beets and mangel wurzel.
d Shelled beans, 60 pounds; velvet beans, 78 pounds.
e White beans.
f Wheat bran.
g English blue-grass seed, 22 pounds; native blue-grass seed, 14 pounds.
h Soy beans, 58 pounds.
i Green unshelled beans, 30 pounds.
j Commercially dry, for all hard woods.
k Fifteen pounds, commercially dry, for all soft woods.
l Dried beans.

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL—(*Continued*).

		Coal.							Corn.				
	Clover Seed.	Coal.*	Anthracite Coal.	Bituminous Coal.	Cannel Coal.	Mineral Coal.	Stone Coal.	Coke.	Corn.*	Corn in Ear, Husked.	Corn in Ear, Unhusked.	Shelled Corn.	Corn Meal.*
U. S.	...	...	...	80	...	...	...	...	56	...	...	...	48
Alabama.	...	...	...	...	...	...	...	...	...	70	75	56	...
Arizona.	...	...	...	...	...	...	...	...	54	...	...	...	...
Arkansas.	60	...	...	...	...	...	...	...	...	70	74	56	48
Colorado.	60	80	...	...	...	80	...	...	...	70	...	...	50
Conn.	60	...	80	...	...	...	...	...	...	...	...	...	...
Florida.	...	...	...	...	...	...	...	...	...	...	70	56	48
Georgia.	60	...	...	...	...	...	80	...	...	70	...	56	48
Idaho.	60	...	...	...	...	...	...	...	...	...	...	...	...
Illinois.	60	...	...	...	...	...	80	...	...	70	...	56	48
Indiana.	60	...	...	...	...	80	...	...	...	(*a*)	...	56	50
Iowa.	60	...	...	...	...	...	80	38	...	*b* 70	...	56	...
Kansas.	60	...	...	...	...	...	80	...	...	*c* 70	...	...	50
Kentucky	60	76	76	76	76	76	76	...	*d* 70	...	...	56	50
Louisiana.	...	...	...	...	...	...	...	...	56	...	...	...	...
Maine.	...	...	...	...	...	...	...	...	56	...	...	...	*e* 50
Mass.	60	...	...	...	...	...	...	...	...	...	...	*f* 50	50
Michigan.	60	...	...	...	...	80	...	...	...	*b* 70	...	56	50
Minnesota	60	80	...	...	...	...	...	...	...	70	...	56	...
Mississippi	60	...	...	...	...	...	80	...	...	72	...	56	48
Missouri.	60	...	...	...	...	80	...	...	...	...	70	56	50
Montana.	60	...	...	...	...	76	...	...	...	70	...	56	50
Nebraska	60	...	...	...	...	...	80	...	...	70	...	56	50
N. Hamp.	...	...	...	...	...	...	...	...	56	...	...	...	50
N. Jersey.	64	...	...	...	...	...	...	...	...	...	...	...	...
New York	60	...	...	...	...	...	...	...	...	...	...	...	50
N. Car.	60	...	...	...	...	...	...	...	...	...	...	...	...
N. Dakota	60	...	...	...	...	...	80	...	...	70	...	56	...
Ohio.	60	...	...	80	70	...	...	40	...	68	...	56	...
Oklahoma	60	...	...	...	...	...	80	...	...	70	...	56	...
Oregon.	60	...	...	...	...	...	...	...	...	...	...	...	...
Penn.	60	*g* 75	...	76	...	...	...	40	58	...	...	...	...
R. Island.	60	80	...	...	...	...	...	40	...	70	...	56	50
S. Car.	...	...	...	...	...	...	...	...	...	...	...	...	*h* 48
S. Dakota	60	...	...	...	...	...	80	...	...	70	...	56	...
Tennessee	*i* 60	...	...	...	...	...	80	40	...	70	*j* 74	56	...
Texas.	60	...	...	...	...	...	80	...	...	70	72	56	...
Vermont.	60	...	...	...	...	...	...	...	...	...	...	...	...
Virginia.	60	...	...	...	...	...	80	...	...	70	...	56	50
Wash.	60	...	...	...	...	...	...	...	...	...	...	...	...
W. Va.	60	...	...	80	...	...	...	...	56	...	...	...	...
Wisconsin	60	...	...	...	...	...	...	...	...	...	...	...	50

* Not defined.

a Corn in ear, 70 pounds until Dec. 1 next after grown; 68 pounds thereafter.
b In the cob.
c Indian corn in ear.
d Corn in ear. from Nov. 1 to May 1, following, 70 pounds; 68 pounds from May 1 to Nov. 1.
e Indian-corn meal.
f Cracked corn.
g Standard weight in borough of Greensburg.
h Standard weight bushel corn meal, bolted or unbolted, 48 pounds.
i Red and white.
j Green unshelled corn, 100 pounds.

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL—(*Continued*).

	Corn Meal, Bolted.	Corn Meal, Unbolted.	Cottonseed.			Cranberries.	Flaxseed (Linseed).	Gooseberries.	(Plastering) Hair.	Hemp Seed.	Herds Grass.	Hungarian Grass Seed.	Indian Corn or Maize.
			Cottonseed.*	Sea Island Cottonseed.	Upland Cottonseed.								
U. S.	...	...	...	...	...	...	56	...	...	...	...	...	...
Alabama.	...	...	32	...	...	...	...	...	...	...	...	...	...
Arkansas.	...	...	33⅓	...	...	...	56	...	...	...	...	...	...
California.	...	...	...	...	...	...	...	...	...	...	...	...	52
Colorado.	...	...	...	...	...	...	...	...	...	44	...	...	56
Conn.	...	...	...	44	30	...	55	...	...	...	45	...	56
Delaware	44	48	...	...	...	...	...	...	...	...	...	...	56
Florida.	...	...	32	46	...	...	...	...	...	...	...	...	...
Georgia.	...	...	30	...	...	...	56	...	8	44	...	...	...
Hawaii.	...	...	...	...	...	...	...	...	...	...	...	...	56
Idaho.	...	...	...	...	...	...	56	...	...	...	...	...	56
Illinois.	...	...	...	...	...	...	56	...	8	44	...	...	...
Indiana.	...	...	...	...	...	33	...	...	...	44	...	...	...
Iowa.	...	...	...	...	...	...	56	40	...	44	...	50	...
Kansas.	...	...	...	...	...	...	56	...	*a*3	44	...	50	*b*56
Kentucky	...	...	...	...	...	...	56	...	8	44	...	50	...
Maine.	...	...	...	...	...	...	...	...	11	...	45	...	...
Mass.	...	...	...	44	30	...	55	...	...	...	45	...	*b*56
Michigan.	...	...	...	...	...	40	56	...	...	44	...	50	...
Minnesota	...	...	...	...	...	36	...	40	*a*8	50	...	48	...
Mississippi	44	48	32	...	...	...	56	...	...	44	...	50	...
Missouri.	...	...	33	...	...	...	56	...	...	44	...	48	...
Montana.	...	...	...	...	...	...	56	...	...	44	...	50	...
Nebraska	...	...	...	...	...	...	56	...	8	44	...	50	...
N. Jersey.	...	...	...	...	...	...	55	...	...	...	...	...	56
New York	...	...	...	44	30	...	55	...	...	...	45	...	56
N. Car.	46	48	30	...	...	...	55	...	...	...	...	...	56
N. Dakota	...	...	...	...	...	...	56	...	...	...	...	...	...
Ohio.	...	...	...	...	...	...	56	...	...	44	...	50	...
Oklahoma	...	...	...	...	...	...	56	...	...	...	...	...	...
Oregon.	...	...	...	...	...	...	...	...	...	...	...	...	56
Penn.	...	...	...	...	...	...	...	...	...	...	...	...	56
R. Island.	...	...	...	44	30	...	56	...	...	44	...	50	...
S. Car.	46	48	30	(*c*)	...	...	...	...	...	...	...	...	...
S. Dakota	...	...	...	...	...	...	56	...	...	...	...	...	...
Tennessee	50	48	23	...	...	...	56	48	8	44	...	48	...
Texas.	...	...	32	...	...	...	56	...	...	44	...	48	...
Vermont.	...	...	...	...	...	...	...	...	...	...	45	...	56
Virginia.	...	...	32	...	...	...	56	...	8	44	12	48	...
Wash.	...	...	...	...	...	...	56	...	...	...	...	...	56
W. Va.	...	...	...	...	...	...	56	...	...	...	...	...	...
Wisconsin	...	...	...	44	30	...	56	...	8	44	...	48	56

* Not defined.

a Unwashed plastering hair, 8 pounds; washed plastering hair, 4 pounds.

b Shelled.
c Matured.

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL—(*Continued*).

	Lime.					Onions.					Peaches.	
	Lime.*	Unslaked Lime.	Malt.	Millet.	Oats.	Onions.*	Onion Sets.	Orchard Grass Seed.	Osage Orange Seed.	Parsnips.	Peaches.*	Dried Peaches, Peeled.
U. S.			34		32							
Alabama					32							38
Arizona					32							
Arkansas				50	32	57						33
California					32							
Colorado	80				32	57						
Conn.	70				32	52				45		33
Florida				50	32	56					*a*54	33
Georgia		80			32	57						38
Hawaii					32							
Idaho					36							
Illinois		80	38		32	57						
Indiana			*b*35	50	32	48		14	33	55		
Iowa	80			50	32	57			32		48	
Kansas		80	32	50	32	57						
Kentucky		35		50	*c*32	57	*d*36	14				39
Maine					*e*32	52				45		
Maryland					26							
Mass.	70				32	52						33
Michigan	70			50	32	54		14	33			28
Minnesota	80			48	32	52		14		42		28
Mississippi		80	38	50	32	57						33
Missouri			38	50	32	57	*f*28	14	36	44	48	33
Montana		80	30		32	57				50		
Nebraska		80	30	50	32	57	25		32			33
N. Hamp					32							
N. Jersey					30	57						33
New York	70				32	57						33
N. Car.					32							
N. Dakota	80			50	32	52						
Ohio	70		34	50	32	55					48	33
Oklahoma	80				32	52						
Oregon					32							28
Penn.					32	50						
R. Island	70		38	50	32	50				50	48	33
S. Dakota	80				32	52						
Tennessee	(*g*)	80		*h*50	32	*i*56	*j*28	14	33	50	*l*50	26
Texas				50	32	57					50	28
Vermont					32	52						
Virginia		80	38	50	30	57	28	14	34			40
Washington					32							28
W. Virginia					32							33
Wisconsin	70	80	34	50	32	57				44		33

* Not defined.

a Green peaches.
b Malt rye.
c Shelled.
d Bottom onion sets.
e Strike measure.
f Top onion sets.
g Slaked lime, 40 pounds.
h German Missouri and Tennessee millet seed.
i Matured onions.
j Button onion sets, 32 pounds.
l Matured.

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL—(*Continued*).

	Dried Peaches, Unpeeled.	Peanuts.	Pears.*	Pease. Ground Pease.	Pease. Green Pease, Unshelled.	Pease. Pease.*	Potatoes. Potatoes.*	Potatoes. Sweet Potatoes.	Potatoes. White Potatoes.	Red Top.	Rough Rice.	Rice Corn.	Rutabagas.
U. S.						60	60						
Alabama.	33					60		55	60				
Arkansas.	33					60	60	50		14			
Colorado.							60						
Conn.	33					60	60	54	60		45		60
D. C.							60						
Florida.		22	60					60	60				
Georgia.	33			25		60		55	60		43		
Idaho.	28		*a* 45				60						
Illinois.	33							50	60				
Indiana.	33						60	55					
Iowa.	33						60	46					
Kansas.	33						60	50				56	
Kentucky				24		60	60	55	60				
Maine.						60	60						60
Maryland.							56						
Mass						60	60	54			45		
Michigan						60		56	60	*b* 14			
Minnesota						60		55	60	*b* 14			52
Mississippi				24		60		60	60				
Missouri.			48		56	*c* 60		56	60	*b* 14			50
Montana.			45			60	60						
Nebraska						60		50	60				
N. Hamp.						60	60						
N. Jersey.						60		54	60				
New York						60		54	60		45		
N. Car.		22				60					44		
N. Dakota						60		46	60				
Ohio						60		50	60				
Oklahoma						60		46	60				
Oregon.			45				60						
Penn.							56						
R. Island.						*c* 60		54	60				
S. Dakota						60		46	60				
Tennessee		23	*d* 56		30	60		50	60	*b* 14			
Texas								55	60				
Vermont						60	60						
Virginia.	32	22				*e* 60		56	56	12			
Wash.			*a* 45				60						
W. Va.							60						
Wisconsin						60		54	60		45		56

* Not defined.

a Green.
b Seed
c Including split pease.
d Matured pears, 56 pounds; dried pears, 26 pounds.
e Black-eyed pease.

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL—(*Continued*)

			Salt.							Turnips.		
	Rye Meal.	Rye.	Salt.*	Fine Salt.	Coarse Salt.	Shorts.*	Sorghum Seed.	Tomatoes.	Timothy Seed.	Turnips.*	Common English Turnips.	Wheat.
U. S.	....	56	....	....	....	....	....	....	....	....	....	60
Alabama.	....	56	....	....	....	....	....	....	....	55	....	60
Arizona.	....	56	....	....	....	....	....	....	....	....	....	60
Arkansas.	....	56	50	....	....	....	50	....	60	57	....	60
California.	....	54	....	....	....	....	....	....	....	....	....	60
Colorado.	....	56	80	....	....	....	....	....	45	....	....	60
Conn.	50	56	....	50	70	20	....	....	....	....	50	60
Delaware.	....	....	....	....	....	....	....	....	....	....	....	60
Florida.	....	56	60	....	....	....	56	....	....	54	....	60
Georgia.	....	56	....	....	....	....	....	....	45	55	....	60
Hawaii.	....	56	....	....	....	....	....	....	....	....	....	60
Idaho.	....	56	....	....	....	....	....	....	....	....	....	60
Illinois.	....	56	....	55	50	....	....	....	45	55	....	60
Indiana.	....	56	50	....	....	....	....	....	45	55	....	60
Iowa.	....	56	50	....	....	....	*a*30	....	45	....	....	60
Kansas.	....	56	50	....	....	....	56	....	45	55	....	60
Kentucky.	....	56	50	55	....	....	....	....	45	60	....	60
Louisiana.	....	56	....	....	....	....	....	....	....	....	....	60
Maine.	50	50	....	60	70	....	....	....	....	....	50	60
Maryland.	....	....	....	....	....	....	....	60	....	....	....	....
Mass.	50	56	....	50	70	20	....	....	45	....	....	60
Michigan.	....	56	56	....	....	....	....	....	45	58	....	60
Minnesota.	....	56	....	....	....	....	57	....	45	....	....	60
Mississippi.	....	56	50	....	....	....	42	....	45	55	....	60
Missouri.	....	56	50	....	....	....	42	45	45	....	42	60
Montana.	....	56	50	....	....	....	....	....	45	50	....	60
Nebraska.	....	56	50	....	....	....	30	....	45	55	....	60
N. Hamp.	50	56	....	....	....	....	....	....	....	....	....	60
N. Jersey.	....	56	....	....	....	....	....	....	....	....	....	60
New York.	50	56	....	56	70	20	....	....	45	....	....	60
N. Carolina.	....	56	....	....	....	....	....	....	....	....	....	60
N. Dakota.	....	56	80	....	....	....	....	....	45	60	....	60
Ohio.	....	56	....	....	....	....	....	56	45	60	....	60
Oklahoma.	....	56	80	....	....	....	....	....	42	60	....	60
Oregon.	....	56	....	....	....	....	....	....	....	....	....	60
Penn.	....	56	....	*c*62	85	....	....	....	....	....	....	60
R. Island.	50	56	....	50	70	20	....	56	45	50	....	60
S Dakota.	....	56	80	....	....	....	....	....	42	60	....	60
Tennessee.	....	56	50	....	....	....	50	56	45	50	....	60
Texas	....	56	50	....	....	....	....	55	45	55	....	60
Vermont.	....	56	70	....	....	....	....	....	45	60	....	*b*60
Virginia.	....	56	50	....	....	....	....	....	45	55	....	60
Washington.	....	56	....	....	....	....	....	....	....	....	....	60
W. Virginia.	....	56	....	....	....	....	....	....	45	....	....	60
Wisconsin.	50	56	....	50	70	20	....	....	45	42	....	60

* Not defined.

a Sorghum saccharatum seed.
b India wheat, 46 pounds.
c Ground salt, 70 pounds.

RULES RELATIVE TO THE CIRCLE.

To Find Circumference:

Multiply diameter by 3.1416,
or divide " " 0.3183.

To Find Diameter:

Multiply circumference by 0.3183,
or divide " " 3.1416.

To Find Radius:

Multiply circumference by 0.15915,
or divide " " 6.28318.

To Find Side of an Inscribed Square:

Multiply diameter by 0.7071,
or multiply circumference by 0.2251,
" divide " " 4.4428.

To Find Side of an Equal Square:

Multiply diameter by 0.8862,
or divide " " 1.1284,
" multiply circumference by 0.2821,
" divide " " 3.545.

Square.

A side multiplied by 1.1442 equal diameter of its circumscribing circle.

A side multiplied by 4.443 equal circumference of its circumscribing circle.

A side multiplied by 1.128 equal diameter of an equal circle.

A side multiplied by 3.547 equal circumference of an equal circle.

Square inches multiplied by 1.273 equal circle inches of an equal circle.

To Find the Area of a Circle:

Multiply circumference by one-quarter of the diameter,
or multiply the square of diameter by 0.7854,
" " " " " circumference " 0.07958,
" " " " " ½ diameter " 3.1416.

To Find the Surface of a Sphere or Globe:

Multiply the diameter by the circumference,
or multiply the square of diameter by 3.1416,
" " four times the square of radius by 3.1416.

To Find the Weight of Brass and Copper Sheets, Rods, and Bars:

Ascertain the number of cubic inches in piece and multiply same by weight per cubic inch.

Brass, 0.2972.

Copper, 0.3212.

Or multiply the length by the breadth (in feet) and product by weight in pounds per square foot.

TABLE TO FIND AREAS, ETC., OF POLYGONS.

Name of Polygon.	No. of Sides.	A Area.	B Radius of Circumscribed Circle.	C Length of the Side.	D Radius of Inscribed Circle.	Angle Contained between Two Sides.
Triangle.......	3	0.433013	0.5773	1.732	0 2887	60°
Tetragon......	4	1	0.7071	1.4142	0.5	90°
Pentagon......	5	1.720477	0.8506	1 1756	0.6882	108°
Hexagon......	6	2.598076	1	1	0.866	120°
Heptagon.....	7	3.633912	1.1524	0.8677	1 0383	128.57°
Octagon.......	8	4.828427	1.3066	0.7653	1.2071	135°
Nonagon......	9	6 181824	1.4619	0.684	1 3737	140°
Decagon.......	10	7.694209	1.618	0 618	1 5383	144°
Undecagon....	11	9 36564	1.7747	0 5634	1.7028	147 27°
Dodecagon...	12	11.196152	1.9319	0 5176	1.866	150°

To find the area of a regular polygon when the length of one side is given: Multiply the square of the side by the multiplier opposite to the name of the polygon in column A of the following table.

To compute the radius of a circumscribing circle when the length of one side is given: Multiply the length of a side of the polygon by the number in column B.

To compute the length of a side of a polygon that is contained in a given circle when the radius of the circle is given: Multiply the radius of the circle by the number opposite the name of the desired polygon in column C.

To compute the radius of a circle that can be inscribed in a given polygon when the length of a side is given: Multiply the length of a side of the polygon by the number opposite the name of the polygon in column D.

MULTIPLIERS FOR FACILITATING CALCULATIONS.

Cubic inches × .4103 = lbs. of lead.

Cubic inches × .3225 = lbs. of copper.

Cubic inches × .328 = lbs. of cast copper.

Cubic inches × .268 = lbs. of tin.

Cubic inches × .304 = lbs. of brass.

Cubic inches × .253 = lbs. of zinc.

Cubic inches × .260 = lbs. of cast iron.

Cubic inches × .282 = lbs. of wrought iron.

Cubic inches × .004329 = U. S. gallons.

Cubic inches × .00058 = cubic feet.

Cubic inches × .000466 = U. S. bushel.

Cubic inches of water × .03617 = lbs. avoir.

One cubic inch of water = .0361 lb.

Cubic feet × .03704 = cubic yards.

Cubic feet × .8036 = U. S. bushel.

Cubic feet × 7.48 = U. S. gallons.

Cubic feet of water × 62.42 = lbs. avoir.

One cubic foot of water = 62.42 lbs. avoir.

1.6 cubic feet of water = 1 cwt. (100).

32.04 cubic feet of water = 1 ton (2000).

1.8 cubic feet of water = 1 cwt. (112).

35.88 cubic feet of water = 1 ton (2240).

Square inches × .007 = square feet.

Square feet × .111 = square yards.

Circular inches × .00546 = square feet.

183.346 circular inches = 1 square foot.

Cylindrical inches × .0004546 = cubic feet.

Cylindrical inches × .0034 = U. S. gallons.

Cylindrical inches of water × .02842 = lbs. avoir.

Cylindrical feet of water × 49.1 = lbs. avoir.

Cylindrical feet × 5.874 = U. S. gallons.

One cylindrical inch of water = .0284 lb.

One cylindrical foot of water = 49.10 lbs.

2200 cylindrical inches = 1 cubic foot.

U. S. bushel × .0495 = cubic yards.

" " × 1.2446 = " feet.

" " × 2150.42 = " inches.

U. S. gallons × .13367 = cubic feet.
U. S. gallon liquid measure × 231 = cubic inches.
13.44 U. S. gal. of water = 1 cwt. (112).
268.8 " " " " = 1 ton (2240).
12 " " " " = 1 cwt. (100).
240 " " " " = 1 ton (2000).
One gallon of water = 8.34 lbs.
One gallon = .13368056 cubic foot.
Lbs. avoirdupois × .009 = cwt. (112).
" " × .00045 = tons (2240).
One pound of water = 27.7 cubic inches.
One pound of water = .16 cubic foot.

Lineal feet	× .00019	= miles.
" yards	× .0006	= "
" links	× .22	= yards.
" "	× .66	= feet.
" feet	× 1.5	= links.
Square yards	× .0002067	= acres.
Acres	× 4840	= square yards.
Width in chains × 8.		= acres per mile.

Velocity in feet per second × 68 = miles per hour.
Velocity in feet per second × .60 = feet per minute.
Velocity in feet per second × .20 = yards per minute.
Inches per second × 5 = feet per minute.
Inches per second × 300 = feet per hour.
Head of water in feet = pressure of water in lbs. per square foot × .016.
Head in feet × .434 = lbs. per square inch.
Pounds per square inch × 2.3 = head in feet.
Pressure of water in lbs. per square foot = head in feet × 62.32.
One pound pressure of water = 2.042-inch column of mercury.
Column of water 12 inches high, 1 inch diameter = .341 lb.
One atmosphere = 2116.3 lbs. per square foot.
One atmosphere = 33.947 feet of water at 62 degrees Fahrenheit.
One circular mill is the area of a circle .001 inch in diameter.
1,000,000 circular mills = one circular inch.

AREAS OF CIRCLES AND SIDES OF SQUARES OF SAME AREA.

(Diameter multiplied by .8862 equals sides of an equal square.)

Diameter of Circle in Inches.	Area of Circle in Square Inches.	Sides of Square of Same Area in Square Inches.	Diameter of Circle in Inches.	Area of Circle in Square Inches.	Sides of Square of Same Area in Square Inches.	Diameter of Circle in Inches.	Area of Circle in Square Inches.	Sides of Square of Same Area in Square Inches.
1	.785	.89	21	346.36	18.61	41	1320.26	36.34
1½	1.767	1.33	21½	363.05	19.05	41½	1352.66	36.78
2	3.142	1.77	22	380.13	19.50	42	1385.45	37.22
2½	4.909	2.22	22½	397.61	19.94	42½	1418.63	37.66
3	7.069	2.66	23	415.48	20.38	43	1452.20	38.11
3½	9.621	3.10	23½	433.74	20.83	43½	1486.17	38.55
4	12.566	3.54	24	452.39	21.27	44	1520.53	38.99
4½	15.904	3.99	24½	471.44	21.71	44½	1555.29	39.44
5	19.635	4.43	25	490.88	22.16	45	1590.43	39.88
5½	23.758	4.87	25½	510.71	22.60	45½	1625.97	40.32
6	28.274	5.32	26	530.93	23.04	46	1661.91	40.77
6½	33.183	5.76	26½	551.55	23.49	46½	1698.23	41.21
7	38.485	6.20	27	572.56	23.93	47	1734.95	41.65
7½	44.179	6.65	27½	593.96	24.37	47½	1772.06	42.10
8	50.266	7.09	28	615.75	24.81	48	1809.56	42.58
8½	56.745	7.53	28½	637.94	25.26	48½	1847.46	42.98
9	63.617	7.98	29	660.52	25.70	49	1885.75	43.43
9½	70.882	8.42	29½	683.49	26.14	49½	1924.43	43.87
10	78.540	8.86	30	706.86	26.59	50	1963.50	44.31
10½	86.590	9.30	30½	730.62	27.03	50½	2002.97	44.75
11	95.03	9.75	31	754.77	27.47	51	2042.83	45.20
11½	103.87	10.19	31½	779.31	27.92	51½	2083.08	45.64
12	113.10	10.63	32	804.25	28.36	52	2123.72	46.08
12½	122.72	11.08	32½	829.58	28.80	52½	2164.76	46.53
13	132.73	11.52	33	855.30	29.25	53	2206.19	46.97
13½	143.14	11.96	33½	881.41	29.69	53½	2248.01	47.41
14	153.94	12.41	34	907.92	30.13	54	2290.23	47.86
14½	165.13	12.85	34½	934.82	30.57	54½	2332.83	48.30
15	176.72	13.29	35	962.11	31.02	55	2375.83	48.74
15½	188.69	13.74	35½	989.80	31.46	55½	2419.23	49.19
16	201.06	14.18	36	1017.88	31.90	56	2463.01	49.63
16½	213.83	14.62	36½	1046.35	32.35	56½	2507.19	50.07
17	226.98	15.07	37	1075.21	32.79	57	2551.76	50.51
17½	240.53	15.51	37½	1104.47	33.23	57½	2596.73	50.96
18	254.47	15.95	38	1134.12	33.68	58	2642.09	51.40
18½	268.80	16.40	38½	1164.16	34.12	58½	2687.84	51.84
19	283.53	16.84	39	1194.59	34.56	59	2733.89	52.29
19½	298.65	17.28	39½	1225.42	35.01	59½	2780.51	52.73
20	314.16	17.72	40	1256.64	35.45	60	2827.74	53.17
20½	330.06	18.17	40½	1288.25	35.89			

DECIMALS OF A FOOT FOR EACH $\frac{1}{64}$ OF AN INCH.

Inch.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″
0	0	.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167
$\frac{1}{64}$	.0013	.0846	.1680	.2513	.3346	.4180	.5013	.5846	.6680	.7513	.8346	.9180
$\frac{1}{32}$	.0026	.0859	.1693	.2526	.3359	.4193	.5026	.5859	.6693	.7526	.8359	.9193
$\frac{3}{64}$	.0039	.0872	.1706	.2539	.3372	.4206	.5039	.5872	.6706	.7539	.8372	.9206
$\frac{1}{16}$	.0052	.0885	.1719	.2552	.3385	.4219	.5052	.5885	.6719	.7552	.8385	.9219
$\frac{5}{64}$	.0065	.0898	.1732	.2565	.3398	.4232	.5065	.5898	.6732	.7565	.8398	.9232
$\frac{3}{32}$	.0078	.0911	.1745	.2578	.3411	.4245	.5078	.5911	.6745	.7578	.8411	.9245
$\frac{7}{64}$	.0091	.0924	.1758	.2591	.3424	.4258	.5091	.5924	.6758	.7591	.8424	.9258
$\frac{1}{8}$	.0104	.0937	.1771	.2604	.3437	.4271	.5104	.5937	.6771	.7604	.8437	.9271
$\frac{9}{64}$	.0117	.0951	.1784	.2617	.3451	.4284	.5117	.5951	.6784	.7617	.8451	.9284
$\frac{5}{32}$	.0130	.0964	.1797	.2630	.3464	.4297	.5130	.5964	.6797	.7630	.8464	.9297
$\frac{11}{64}$	.0143	.0977	.1810	.2643	.3477	.4310	.5143	.5977	.6810	.7643	.8477	.9310
$\frac{3}{16}$	.0156	.0990	.1823	.2656	.3490	.4323	.5156	.5990	.6823	.7656	.8490	.9323
$\frac{13}{64}$	.0169	.1003	.1836	.2669	.3503	.4336	.5169	.6003	.6836	.7669	.8503	.9336
$\frac{7}{32}$	.0182	.1016	.1849	.2682	.3516	.4349	.5182	.6016	.6849	.7682	.8516	.9349
$\frac{15}{64}$	.0195	.1029	.1862	.2695	.3529	.4362	.5195	.6029	.6862	.7695	.8529	.9362
$\frac{1}{4}$	.0208	.1042	.1875	.2708	.3542	.4375	.5208	.6042	.6875	.7708	.8542	.9375
$\frac{17}{64}$	.0221	.1055	.1888	.2721	.3555	.4388	.5221	.6055	.6888	.7721	.8555	.9388
$\frac{9}{32}$	.0234	.1068	.1901	.2734	.3568	.4401	.5234	.6068	.6901	.7734	.8568	.9401
$\frac{19}{64}$	.0247	.1081	.1914	.2747	.3581	.4414	.5247	.6081	.6914	.7747	.8581	.9414
$\frac{5}{16}$	.0260	.1094	.1927	.2760	.3594	.4427	.5260	.6094	.6927	.7760	.8594	.9427
$\frac{21}{64}$	.0273	.1107	.1940	.2773	.3607	.4440	.5273	.6107	.6940	.7773	.8607	.9440
$\frac{11}{32}$	.0286	.1120	.1953	.2786	.3620	.4453	.5286	.6120	.6953	.7786	.8620	.9453
$\frac{23}{64}$	.0299	.1133	.1966	.2799	.3633	.4466	.5299	.6133	.6966	.7799	.8633	.9466
$\frac{3}{8}$	.0312	.1146	.1979	.2812	.3646	.4479	.5312	.6146	.6979	.7812	.8646	.9479
$\frac{25}{64}$	.0326	.1159	.1992	.2826	.3659	.4492	.5326	.6159	.6992	.7826	.8659	.9492
$\frac{13}{32}$	.0339	.1172	.2005	.2839	.3672	.4505	.5339	.6172	.7105	.7839	.8672	.9505
$\frac{27}{64}$	.0352	.1185	.2018	.2852	.3685	.4518	.5352	.6185	.7018	.7852	.8685	.9518
$\frac{7}{16}$	.0365	.11 8	.2031	.2865	.3698	.4531	.5365	.6198	.7031	.7865	.8698	.9531
$\frac{29}{64}$	.0378	.1211	.2044	.2878	.3711	.4544	.5378	.6211	.7044	.7878	.8711	.9544
$\frac{15}{32}$	.0391	.1224	.2057	.2891	.3724	.4557	.5391	.6224	.7057	.7891	.8724	.9557
$\frac{31}{64}$	.0404	.1237	.2070	.2904	.3737	.4570	.5404	.6237	.7070	.7904	.8737	.9570
$\frac{1}{2}$	.0417	.1250	.2083	.2917	.3750	.4583	.5417	.6250	.7083	.7917	.8750	.9583
$\frac{33}{64}$	.0430	.1263	.2096	.2930	.3763	.4596	.5430	.6263	.7096	.7930	.8763	.9596
$\frac{17}{32}$	.0443	.1276	.2109	.2943	.3776	.4609	.5443	.6276	.7109	.7943	.8776	.9609
$\frac{35}{64}$	.0456	.1289	.2122	.2956	.3789	.4622	.5456	.6289	.7122	.7956	.8789	.9622
$\frac{9}{16}$	.0469	.1302	.2135	.2969	.3802	.4635	.5469	.6302	.7135	.7969	.8802	.9635
$\frac{37}{64}$	.0482	.1315	.2148	.2982	.3815	.4648	.5482	.6315	.7148	.7982	.8815	.9648
$\frac{19}{32}$	.0495	.1328	.2161	.2995	.3828	.4661	.5495	.6328	.7161	.7995	.8828	.9661
$\frac{39}{64}$	.0508	.1341	.2174	.3008	.3841	.4674	.5508	.6341	.7174	.8008	8841	.9674
$\frac{5}{8}$	.0521	.1354	.2188	.3021	.3854	.4688	.5521	.6354	.7188	.8021	.8854	.9688
$\frac{41}{64}$	.0534	.1367	.2201	.3034	.3867	.4701	.5534	.6367	.7201	.8034	.8867	.9701
$\frac{21}{32}$	.0547	.1380	.2214	.3047	.3880	.4714	.5547	.6380	.7214	.8047	.8880	.9714
$\frac{43}{64}$	.0560	.1393	.2227	.3060	.3893	.4727	.5560	.6393	.7227	.8060	.8893	.9727
$\frac{11}{16}$	.0573	.1406	.2240	.3073	.3906	.4740	.5573	.6406	.7240	.8073	.8906	.9740
$\frac{45}{64}$	.0586	.1419	.2253	.3086	.3919	.4753	.5586	.6419	.7253	.8086	.8919	.9753
$\frac{23}{32}$	.0599	.1432	.2266	.3099	.3932	.4766	.5599	.6432	.7266	.8099	.8932	.9766
$\frac{47}{64}$	.0612	.1445	.2279	.3112	.3945	.4779	.5612	.6445	.7279	.8112	.8945	.9779
$\frac{3}{4}$	.0625	.1458	.2292	.3125	.3958	.4792	.5625	.6458	.7292	.8125	.8958	.9792

DECIMALS OF A FOOT FOR EACH $\frac{1}{64}$ OF AN INCH—(*Continued*).

Inch.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″
$\frac{49}{64}$	.0638	.1471	.2305	.3138	.3971	.4805	.5638	.6471	.7305	.8138	.8971	.9805
$\frac{25}{32}$	.0651	.1484	.2318	.3151	.3984	.4818	.5651	.6484	.7318	.8151	.8984	.9818
$\frac{51}{64}$	.0664	.1497	.2331	.3164	.3997	.4831	.5664	.6497	.7331	.8164	.8997	.9831
$\frac{13}{16}$	.0677	.1510	.2344	.3177	.4010	.4844	.5677	.6510	.7344	.8177	.9010	.9844
$\frac{53}{64}$	.0690	.1523	.2357	.3190	.4023	.4857	.5690	.6523	.7357	.8190	.9023	.9857
$\frac{27}{32}$	.0703	.1536	.2370	.3203	.4036	.4870	.5703	.6536	.7370	.8203	.9036	.9870
$\frac{55}{64}$	.0716	.1549	.2383	.3216	.4049	.4883	.5716	.6549	.7383	.8216	.9049	.9883
$\frac{7}{8}$	.0729	.1562	.2396	.3229	.4062	.4896	.5729	.6562	.7396	.8229	.9062	.9896
$\frac{57}{64}$	.0742	.1576	.2409	.3242	.4076	.4909	.5742	.6576	.7409	.8242	.9076	.9909
$\frac{29}{32}$	.0755	.1589	.2422	.3255	.4089	.4922	.5755	.6589	.7422	.8255	.9089	.9922
$\frac{59}{64}$	.0768	.1602	.2435	.3268	.4102	.4935	.5768	.6602	.7435	.8268	.9102	.9935
$\frac{15}{16}$	.0781	.1615	.2448	.3281	.4115	.4948	.5781	.6615	.7448	.8281	.9115	.9948
$\frac{61}{64}$	.0794	.1628	.2461	.3294	.4128	.4961	.5794	.6628	.7461	.8294	.9128	.9961
$\frac{31}{32}$	.0807	.1641	.2474	.3307	.4141	.4974	.5807	.6641	.7474	.8307	.9141	.9974
$\frac{63}{64}$	.0820	.1654	.2487	.3320	.4154	.4987	.5820	.6654	.7487	.8320	.9154	.9987
1												1.0000

DECIMALS OF AN INCH FOR EACH $\frac{1}{64}$TH.

$\frac{1}{32}$ds.	$\frac{1}{64}$ths.	Decimal.	Fraction.	$\frac{1}{32}$ds.	$\frac{1}{64}$ths.	Decimal.	Fraction.
	1	.015625			33	.515625	
1	2	.03125		17	34	.53125	
	3	.046875			35	.546875	
2	4	.0625	$\frac{1}{16}$	18	36	.5625	$\frac{9}{16}$
	5	.078125			37	.578125	
3	6	.09375		19	38	.59375	
	7	.109375			39	.609375	
4	8	.125	$\frac{1}{8}$	20	40	.625	$\frac{5}{8}$
	9	.140625			41	.640625	
5	10	.15625		21	42	.65625	
	11	.171875			43	.671875	
6	12	.1875	$\frac{3}{16}$	22	44	.6875	$\frac{11}{16}$
	13	.203125			45	.703125	
7	14	.21875		23	46	.71875	
	15	.234375			47	.734375	
8	16	.25	$\frac{1}{4}$	24	48	.75	$\frac{3}{4}$
	17	.265625			49	.765625	
9	18	.28125		25	50	.78125	
	19	.296875			51	.796875	
10	20	.3125	$\frac{5}{16}$	26	52	.8125	$\frac{13}{16}$
	21	.328125			53	.828125	
11	22	.34375		27	54	.84375	
	23	.359375			55	.859375	
12	24	.375	$\frac{3}{8}$	28	56	.875	$\frac{7}{8}$
	25	.390625			57	.890625	
13	26	.40625		29	58	.90625	
	27	.421875			59	.921875	
14	28	.4375	$\frac{7}{16}$	30	60	.9375	$\frac{15}{16}$
	29	.453125			61	.953125	
15	30	.46875		31	62	.96875	
	31	.484375			63	.984375	
16	32	.5	$\frac{1}{2}$	32	64	1.	1

FIRST AID TO THE INJURED.

USEFUL SUGGESTIONS IN CASES OF ACCIDENTS TO MECHANICS.

Electric Shock.—The patient should be immediately placed in position for artificial respiration, preferably on a table with a cushion under his shoulders to elevate them slightly. Then bring his arms down until his hands rest on his chest, grasp his wrists and press firmly against the lower walls of the chest for a few seconds, then raise the arms outward and upward until the hands meet beyond the head, drawing firmly upward for a few seconds; repeat this procedure ten or fifteen times a minute.

Bleeding.—If blood spurts from wound, an artery is divided; bind limb tightly above with India-rubber tubing, strap, handkerchief, or scarf, or bend the limb forcibly at next joint above wound, or press flat hand or stone where blood is flowing. If blood flows freely, but does not spurt, a vein is divided; then apply same measures as in case of wounded artery, but below the wound. If scalp is wounded make a pad of cloth or waste, and bandage very tightly over wound with folded pocket-handkerchief.

Burns and Scalds.—Apply lint, cotton, wool, or waste soaked in oil and lime-water, and bind the same on with handkerchief. If necessary to remove clothes cut them off by running knife or scissors along seams.

Broken Leg.—Pull on leg steadily and firmly until it is of same length as sound one. Roll up a coat or empty sack into form of a cushion, carefully place leg upon it, then bind the two together with scarfs or handkerchiefs. Do not lift patient from the ground until stretcher is close at hand. Take great pains, by careful lifting, to prevent broken bone coming through skin.

Broken Thigh.—Take hold of ankle and, by steady traction, pull limb to same length as sound one; another person must then tie knees together, and afterward the ankles. Both limbs should then be laid over a sack of straw, or folded coat, so as to bend the knees. Patient should on no account be moved until stretcher or cart is close at hand.

Broken Arm. — Pull arm to length of sound one. Apply two splints, one outside and the other inside, binding them firmly on with pocket-handkerchiefs. The best splints are made by folding newspapers to necessary length, binding them above and below seat of fracture; anything hard and light, of suitable size, would act equally well; for instance, wood, pasteboard, twigs, leather, etc.

A FEW ODDS AND ENDS FOR THE NOON-HOUR.

A Very Deceptive Problem. — Cut a piece of paper 8 inches square, containing 64 square inches, to fill a space 5 × 13 inches and containing 65 square inches.

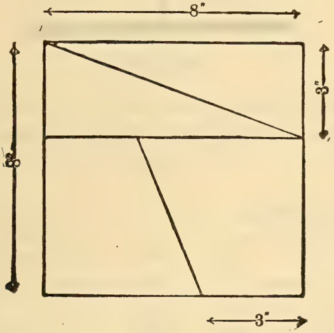


Fig. 185.

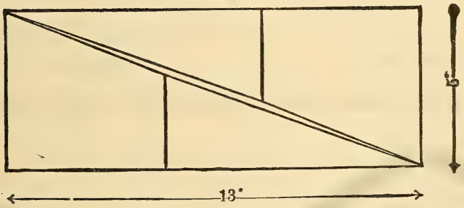


Fig. 186.

Cut the square piece of paper as shown by Fig. 185 and put together as shown by Fig. 186, it will then measure 5 × 13 inches, but if the sides of the 13-inch figure are kept straight there

will be an opening in the center as shown. This explains the extra inch.

Which line is the longer, the horizontal or the perpendicular in Fig. 187? Speak quick.

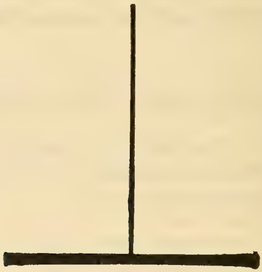


Fig. 187.

To Cut a Block 12 × 12 Inches to Fill a Hole 9 × 16 Inches. — Cut as shown by Fig. 188 and put together as shown by Fig. 189.

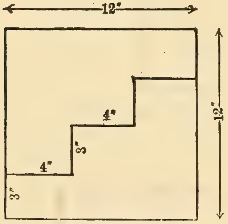


Fig. 188.

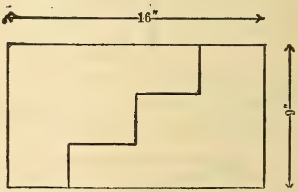


Fig. 189.

Which is the greater distance, *A* to *B* or *B* to *C*, Fig. 190.

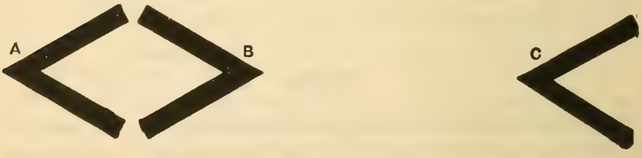


Fig. 190.

Draw Fig. 191 without lifting the points of the pencil from the paper, making one continuous line.

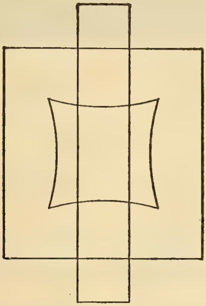


Fig 191.

To Cut a Five-point Star at One Cut.—Take a square piece of paper and fold it as shown by Fig. 192, 1 to 5, the first

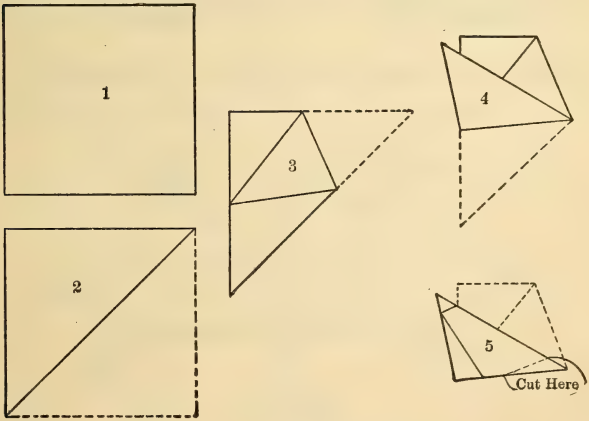


Fig. 192.

fold is shown at 2, the second fold is shown at 3, etc., whe: folded cut on the line shown in 5.

THE LEAKING-SHIP PROBLEM. — A ship at sea strikes a rock and knocks a hole in the bottom 8 × 15 inches. The ship's carpenter has a piece of board 10 × 12 inches. How can he cut it to fill the hole?

Cut it as shown by Fig. 193, and put together as shown by Fig. 194.

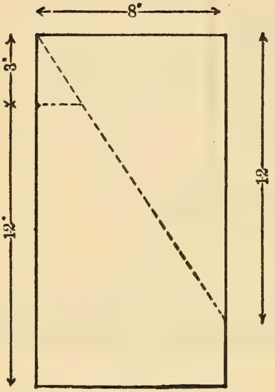


Fig. 193.

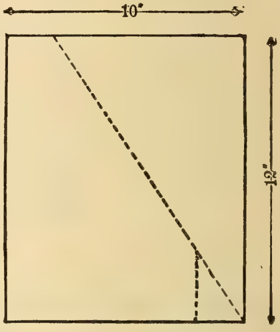


Fig. 194.

Which of the horizontal lines in Fig. 195 is the longer?

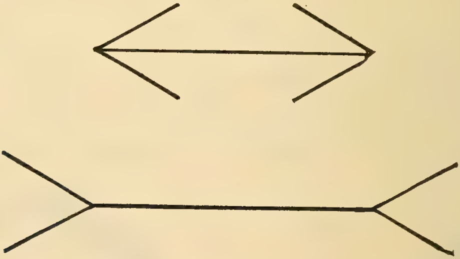


Fig. 195.

Which of the lower diagonal lines in Fig. 196 is in line with the line above ?

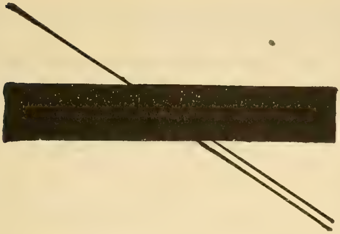


Fig. 196.

Are the horizontal lines in Fig. 197 parallel or not?

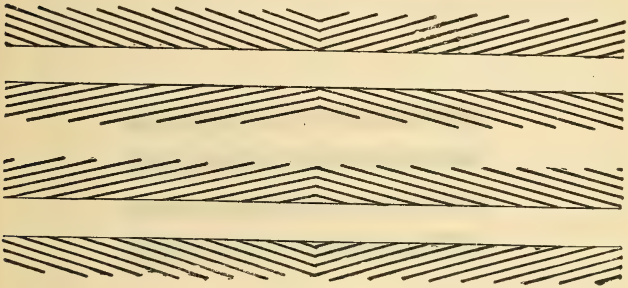


Fig. 197.

Which of the dotted lines in the cross is the longer?

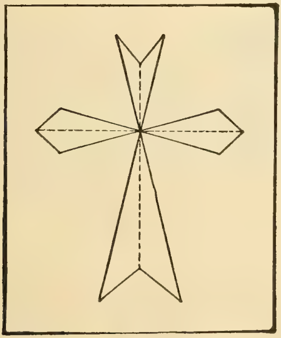


Fig. 198.

Which of the circular sections is the longer, *A* or *B?*

Are the heavy lines in Fig. 200 parallel?

Fig. 201 shows a perfectly straight rule laid over a number of concentric circular rings. As will be seen it gives the rule a

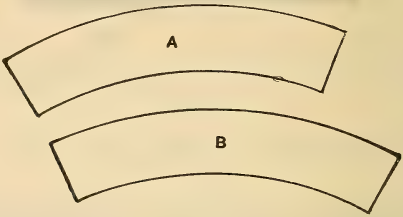


Fig. 199

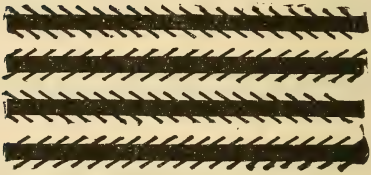


Fig. 200.

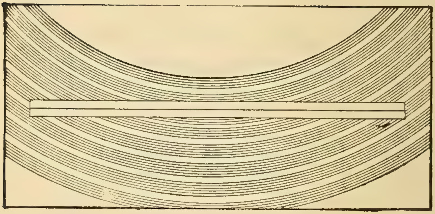


Fig. 201.

curved appearance. The circular rings also appear distorted, as the rings on one side of the rule do not appear to be a continuation of those on the other side, but this can be proved by sighting along the lines

WAGE-TABLE.

Explanation.—Find the number of days or hours employed, in the left-hand columns, and follow this line out to the column under the rate per day or hour, where will be found the sum due.

Rate per hour, cents		25	28	31.25	34.38	37.5	40	40.62	43.75	46.87	50	53.12	56.25	59.37	62.5	65.62	68.75	71.87	75
Rate per day, dollars		2.00	2.25	2.50	2.75	3.00	3.20	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	5.50	5.75	6.00
Days of 8 Hours.	Hours.	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct
	½	.13	.14	.16	.17	.19	.20	.20	.22	.23	.25	.26	.28	.30	.31	.33	.34	.36	.38
	1	.25	.28	.31	.34	.38	.40	.41	.44	.47	.50	.53	.56	.59	.63	.66	.69	.72	.75
	½	.38	.42	.47	.52	.56	.60	.61	.66	.70	.75	.80	.84	.89	.94	.99	1.03	1.08	1.13
¼	2	.50	.56	.63	.69	.75	.80	.81	.88	.94	1.00	1.06	1.13	1.19	1.25	1.31	1.38	1.44	1.50
	½	.63	.70	.78	.86	.94	1.00	1.02	1.09	1.17	1.25	1.33	1.41	1.49	1.56	1.64	1.72	1.80	1.88
	3	.75	.84	.94	1.03	1.13	1.20	1.22	1.31	1.41	1.50	1.59	1.69	1.78	1.88	1.97	2.06	2.16	2.25
	½	.88	.98	1.09	1.20	1.31	1.40	1.42	1.53	1.64	1.75	1.85	1.97	2.08	2.19	2.30	2.41	2.52	2.63
½	4	1.00	1.13	1.25	1.38	1.50	1.60	1.63	1.75	1.88	2.00	2.12	2.25	2.39	2.50	2.62	2.75	2.87	3.00
	½	1.13	1.26	1.41	1.55	1.69	1.80	1.83	1.97	2.11	2.25	2.39	2.53	2.67	2.81	2.95	3.09	3.23	3.38
	5	1.25	1.41	1.56	1.72	1.88	2.00	2.03	2.19	2.34	2.50	2.66	2.81	2.97	3.13	3.28	3.44	3.59	3.75
	½	1.38	1.55	1.72	1.89	2.06	2.20	2.23	2.41	2.58	2.75	2.92	3.09	3.26	3.44	3.61	3.78	3.95	4.13
¾	6	1.50	1.69	1.88	2.06	2.25	2.40	2.44	2.63	2.81	3.00	3.19	3.38	3.56	3.75	3.94	4.13	4.31	4.50
	½	1.63	1.83	2.03	2.23	2.44	2.60	2.64	2.84	3.05	3.25	3.45	3.66	3.86	4.07	4.27	4.47	4.67	4.88
	7	1.75	1.97	2.19	2.41	2.63	2.80	2.84	3.06	3.28	3.50	3.72	3.93	4.16	4.38	4.59	4.81	5.03	5.25
	½	1.88	2.11	2.34	2.58	2.81	3.00	3.05	3.28	3.52	3.75	3.98	4.22	4.45	4.69	4.92	5.16	5.39	5.63
1 day	8	2.00	2.25	2.50	2.75	3.00	3.20	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	5.50	5.75	6.00
	½	2.13	2.39	2.66	2.92	3.19	3.40	3.45	3.72	3.98	4.25	4.51	4.78	5.05	5.31	5.58	5.84	6.11	6.38
	9	2.25	2.53	2.81	3.09	3.38	3.60	3.66	3.94	4.22	4.50	4.78	5.06	5.34	5.63	5.91	6.19	6.47	6.75
	½	2.38	2.67	2.97	3.27	3.56	3.80	3.86	4.16	4.45	4.75	5.05	5.34	5.64	5.94	6.24	6.53	6.83	7.13
1¼	10	2.50	2.81	3.13	3.44	3.75	4.00	4.06	4.38	4.69	5.00	5.31	5.63	5.94	6.25	6.56	6.88	7.19	7.50
	½	2.63	2.95	3.28	3.61	3.94	4.20	4.27	4.59	4.92	5.25	5.58	5.91	6.24	6.56	6.89	7.22	7.55	7.88
	11	2.75	3.09	3.41	3.78	4.13	4.40	4.47	4.81	5.16	5.50	5.84	6.19	6.53	6.88	7.22	7.56	7.91	8.25
	½	2.88	3.23	3.59	3.95	4.31	4.60	4.67	5.03	5.30	5.75	6.11	6.47	6.83	7.19	7.55	7.91	8.27	8.63
1½	12	3.00	3.38	3.75	4.13	4.50	4.80	4.88	5.25	5.63	6.00	6.38	6.75	7.13	7.50	7.87	8.25	8.62	9.00

WAGE-TABLE—(*Continued*).

Explanation.—Find the number of days or hours employed, in the left-hand columns, and follow this line out to the column under the rate per day or hour, where will be found the sum due.

Rate per hour, cents.		25	28	31.25	34.38	37.5	40	40.62	43.75	46.87	50	53.12	56.25	59.37	62.5	65.62	68.75	71.87	75
Rate per day, dollars.		2.00	2.25	2.50	2.75	3.00	3.20	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	5.50	5.75	6.00
Days of 8 Hours.	Hours.	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct
	12½	3.13	3.51	3.91	4.30	4.69	5.00	5.08	5.47	5.86	6.25	6.64	7.03	7.42	7.81	8.20	8.59	8.98	9.38
	13	3.25	3.66	4.06	4.47	4.88	5.20	5.28	5.69	6.00	6.50	6.91	7.31	7.72	8.13	8.53	8.94	9 34	9.75
	½	3.38	3.80	4.22	4.64	5.06	5.40	5.48	5.91	6.33	6.75	7.17	7.59	8.01	8.44	8.86	9.28	9.70	10.13
1¾	**14**	3.50	3.94	4.38	4.81	5.25	5.60	5.69	6.13	6.56	7.00	7.44	7.88	8.31	8.75	9.19	9.63	10.06	10.50
	½	3.63	4.08	4.53	4.93	5.44	5.80	5.89	6.34	6.80	7.25	7.71	8.16	8.61	9.07	9.52	9.97	10.42	10.88
	15	3.75	4.22	4.69	5.16	5.63	6.00	6.09	6.56	7.03	7.50	7.97	8.44	8.91	9.38	9.84	10.31	10.78	11.25
	½	3.88	4.36	4.84	5.33	5.81	6.20	6.30	6.78	7.27	7.75	8.23	8.72	9.20	9.69	10.17	10.66	11.14	11.63
2 days	**16**	4.00	4.50	5.00	5.50	6.00	6.40	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00	10.50	11.00	11.50	12.00
	½	4.13	4.64	5.16	5.67	6.19	6.60	6.70	7.22	7.73	8.25	8.76	9.28	9.80	10.31	10.83	11.34	11.86	12.38
	17	4.25	4.78	5.31	5.84	6.38	6.80	6.91	7.44	7.97	8.50	9.03	9.56	10.09	10.63	11.16	11.69	12.22	12.75
	½	4.38	4.92	5.47	6.02	6.56	7.00	7.11	7.66	8.20	8.75	9.30	9.84	10.39	10.94	11.49	12.03	12.58	13.13
2¼	**18**	4.50	5.06	5.63	6.19	6.75	7.20	7.31	7.88	8.44	9.00	9.56	10.13	10.69	11.25	11.81	12.38	12.94	13.50
	½	4.63	5.20	5.78	6.36	6.94	7.40	7.52	8.09	8.67	9.25	9.83	10.41	10.99	11.56	12.14	12.72	13.30	13.88
	19	4.75	5.34	5.94	6.53	7.13	7.60	7.72	8.31	8.91	9.50	10.09	10.69	11.28	11.88	12.47	13.06	13.66	14.25
	½	4.88	5.48	6.09	6.70	7.31	7.80	7.92	8.53	9.14	9.75	10.36	10.97	11.58	12.19	12.80	13.41	14.04	14.63
2½	**20**	5.00	5.63	6.25	6.88	7.50	8.00	8.13	8.75	9.38	10.00	10.63	11.25	11.88	12.50	13.12	13.75	14.37	15.00
	½	5.13	5.76	6.41	7.05	7.69	8.20	8.33	8.97	9.61	10.25	11.89	11.53	12.17	12.81	13.45	14.09	14.73	15.38
	21	5.25	5.91	6.56	7.22	7.88	8.40	8.53	9.19	9.84	10.50	11.16	11.81	12.47	13.13	13.78	14.44	15.09	15.75
	½	5.38	6.04	6.72	7.39	8.06	8.60	8.73	9.41	10.08	10.75	11.42	12.09	12.76	13.44	14.11	14.78	15.45	16.13
2¾	**22**	5.50	6.19	6.88	7.56	8.25	8.80	8.94	9.63	10.31	11.00	11.69	12.38	13.06	13.75	14.44	15.13	15.81	16.50
	½	5.63	6.33	7.03	7.73	8.44	9.00	9.14	9.84	10.55	11.25	12.96	12.66	13.36	14.07	14.77	15.47	16.17	16.88
	23	5.75	6.47	7.19	7.91	8.63	9.20	9.34	10.06	10.78	11.50	12.22	12.93	13.66	14.38	15.09	15.81	16.53	17.25
	½	5.88	6.61	7.34	8.08	8.81	9.40	9.55	10.28	11.02	11.75	12.48	13.22	13.95	14.69	15.42	16.16	16.89	17.63
3 days	**24**	6.00	6.75	7.50	8.25	9.00	9.60	9.75	10.50	11.25	12.00	12.75	13.50	14.25	15.00	15.75	16.50	17.25	18.00

WAGE-TABLE—(*Continued*).

Explanation.—Find the number of days or hours employed, in the left-hand columns, and follow this line out to the column under the rate per day or hour, where will be found the sum due.

Rate per hour, cents........		25	28	31.25	34.38	37.5	40	40.62	43.75	46.87	50	53.12	56.25	59.37	62.5	65.62	68.75	71.87	75
Rate per day, dollars......		2.00	2.25	2.50	2.75	3.00	3.20	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	5.50	5.75	6.00
Days of 8 Hours.	Hours.	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct
	24½	6.13	6.89	7.66	8.42	9.19	9.80	9.95	10.72	11.48	12.25	13.01	13.78	14.55	15.31	16.08	16.84	17.61	18.38
	25	6.25	7.03	7.81	8.59	9.38	10.00	10.16	10.94	11.72	12.50	13.28	14.06	14.84	15.63	16.41	17.17	17.97	18.75
	½	6.38	7.17	7.97	8.77	9.56	10.20	10.36	11.16	11.95	12.75	13.55	14.34	15.14	15.94	16.74	17.53	18.33	19.13
3¼	26	6.50	7.31	8.13	8.94	9.75	10.40	10.56	11.38	12.19	13.00	13.81	14.63	15.44	16.25	17.14	17.88	18.69	19.50
	½	6.63	7.45	8.28	9.11	9.94	10.60	10.77	11.59	12.42	13.25	14.08	14.91	15.74	16.56	17.39	18.22	19.05	19.88
	27	6.75	7.59	8.44	9.28	10.13	10.80	10.97	11.81	12.66	13.50	14.34	15.19	16.03	16.88	17.72	18.56	19.41	20.25
	½	6.88	7.73	8.59	9.45	10.31	11.00	11.17	12.03	12.89	13.75	14.61	15.47	16.33	17.19	18.05	18.19	19.77	20.63
3½	28	7.00	7.88	8.75	9.63	10.50	11.20	11.38	12.25	13.13	14.00	14.88	15.75	16.63	17.50	18.37	19.25	20.12	21.00
	½	7.13	8.01	8.91	9.80	10.69	11.40	11.58	12.47	13.36	14.25	15.14	16.03	16.92	17.81	18.70	19.59	20.48	21.38
	29	7.25	8.16	9.06	9.97	10.88	11.60	11.78	12.69	13.59	14.50	15.41	16.31	17.22	18.13	19.03	19.94	20.84	21.75
	½	7.38	8.30	9.22	10.14	11.06	11.80	11.98	12.91	13.83	14.75	15.67	16.59	17.51	18.44	19.36	20.28	21.20	22.13
3¾	30	7.50	8.44	9.38	10.31	11.25	12.00	12.19	13.13	14.06	15.00	15.94	16.88	17.81	18.75	19.69	20.63	21.56	22.50
	½	7.63	8.58	9.53	10.48	11.44	12.20	12.39	13.34	14.30	15.25	16.21	17.16	18.11	19.07	20.02	20.97	21.92	22.88
	31	7.75	8.72	9.69	10.66	11.63	12.40	12.59	13.56	14.53	15.50	16.47	17.44	18.41	19.38	20.34	21.31	22.28	23.25
	½	7.88	8.86	9.84	10.83	11.81	12.60	12.80	13.78	14.77	15.75	16.73	17.72	18.70	19.69	20.67	21.66	22.64	23.63
4 days	32	8.00	9.00	10.00	11.00	12.00	12.80	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
	½	8.13	9.14	10.16	11.17	12.19	13.00	13.20	14.22	15.23	16.25	17.26	18.28	19.30	20.31	21.33	22.34	23.36	24.38
	33	8.25	9.28	10.31	11.34	12.38	13.20	13.41	14.44	15.47	16.50	17.53	18.56	19.59	20.63	21.66	22.69	23.72	24.75
	½	8.38	9.42	10.47	11.52	12.56	13.40	13.61	14.66	15.70	16.75	17.80	18.84	19.89	20.94	21.99	23.03	24.08	25.13
4¼	34	8.50	9.56	10.63	11.69	12.75	13.60	13.81	14.88	15.94	17.00	18.06	19.13	20.19	21.25	22.31	23.38	24.44	25.50
	½	8.63	9.70	10.78	11.86	12.94	13.80	14.02	15.09	16.17	17.25	18.33	19.41	20.49	21.56	22.64	23.72	24.80	25.88
	35	8.75	9.84	10.94	12.03	13.13	14.00	14.22	15.31	16.41	17.50	18.59	19.69	20.78	21.88	22.97	24.06	25.16	26.25
	½	8.88	9.98	11.09	12.20	13.31	14.20	14.42	15.53	16.64	17.75	18.85	19.97	21.08	22.19	23.30	24.41	25.52	26.63
4½	36	9.00	10.13	11.25	12.38	13.50	14.40	14.63	15.75	16.88	18.00	19.12	20.25	21.38	22.50	23.62	24.75	25.87	27.00

WAGE-TABLE—(*Continued*).

Explanation.—Find the number of days or hours employed, in the left-hand columns, and follow this line out to the column under the rate per day or hour, where will be found the sum due.

Rate per hour, cents		25	28	31.25	34.38	37.5	40	40.62	43.75	46.87	50	53.12	56.25	59.37	62.5	65.62	68.75	71.87	75
Rate per day, dollars		2.00	2.25	2.50	2.75	3.00	3.20	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	5.50	5.75	6.00
Days of 8 Hours.	Hours	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct	$ ct
	36½	9.13	10.26	11.41	12.55	13.69	14.60	14.83	15.97	17.11	18.25	19.38	20.53	21.68	22.81	23.95	25.09	26.23	27.38
	37	9.25	10.41	11.56	12.72	13.88	14.80	15.03	16.19	17.34	18.50	19.65	20.81	21.97	23.13	24.27	25.44	26.59	27.75
	½	9.38	10.55	11.72	12.89	14.06	15.00	15.23	16.41	17 58	18.75	19.92	21.09	22.27	23.44	24.60	25.78	26.95	28.13
4¾	38	9.50	10.69	11.88	13.06	14.25	15.20	15.44	16.63	17.81	19.00	20.18	21.38	22.57	23.75	24.93	26.13	27.31	28.50
	½	9.63	10.83	12.03	13.23	14.44	15.40	15.64	16.84	18.05	19.25	20.45	21.66	22.87	24.06	25.26	26.47	27.67	28.88
	39	9.75	10.97	12.19	13.41	14.63	15.60	15.84	17.06	18.28	19.50	20.71	21.93	23.16	24.38	25.58	26.81	28.03	29.25
	½	9.88	11.11	12.34	13.58	14.81	15.80	16.05	17.28	18.52	19.75	20.97	22.22	23.46	24.69	25.92	27.16	28.39	29.63
5 days	40	10.00	11.25	12.50	13.75	15.00	16.00	16.25	17.50	18.75	20.00	21.24	22.50	23.75	25.00	26.25	27.50	28.75	30.00
	½	10.13	11.39	12.66	13.92	15.19	16.20	16.45	17.72	18.98	20.25	21.51	22.78	24.05	25.31	26.58	27.84	29.11	30.38
	41	10.25	11.53	12.81	14.09	15.38	16.40	16.66	17.94	19.22	20.50	21.78	23.06	24.34	25.63	26.91	28.19	29.47	30.75
	½	10.38	11.67	12.97	14.27	15.56	16.60	16.86	18.16	19.45	20.75	22.04	23.34	24.64	25.94	27.24	28.53	29.83	31.13
5¼	42	10.50	11.81	13.13	14.44	15.75	16.80	17.06	18.38	19.69	21.00	22.30	23.63	24.94	26.25	27.56	28.88	30.19	31.50
	½	10.63	11.95	13.28	14.61	15.94	17.00	17.27	18.59	19.92	21.25	22.57	23.91	25.24	26.56	27.89	29.22	30.55	31.88
	43	10.75	12.09	13.44	14.78	16.13	17.20	17.47	18.81	20.16	21.50	22.83	24.19	25.53	26.88	28.22	29.56	30.91	32.25
	½	10.88	12.23	13.59	14.95	16.31	17.40	17.67	19.03	20.39	21.75	23.10	24.47	25.83	27.19	28.55	29.91	31.27	32.63
5½	44	11.00	12.38	13.75	15.13	16.50	17.60	17.88	19.25	20.63	22.00	23.36	24.75	26.14	27.50	28.87	30.25	31.62	33.00
	½	11.13	12.51	13.91	15.30	16 69	17.80	18.08	19.47	20.86	22.25	23.63	25.03	26.42	27.81	29.20	30.59	31.98	33.38
	45	11.25	12.66	14.06	15.47	16.88	18.00	18.28	19.69	21.09	22.50	23.90	25.31	26.73	28.13	29.53	30.94	32.34	33.75
	½	11.38	12.80	14.22	15.64	17.06	18.20	18.48	19.91	21.33	22.75	24.17	25.59	27.01	28.44	29.86	31.28	32.70	34.13
5¾	46	11.50	12.94	14.38	15.81	17.25	18.40	18.69	20.13	21.56	23.00	24.43	25.88	27.32	28.75	30.19	31.63	33.06	34.50
	½	11.63	13.08	14.53	15.98	17.44	18.60	18.89	20.34	21.80	23.25	24.70	26.16	27.61	29.07	30.52	31.97	33.42	34.88
	47	11.75	13.22	14.69	15.16	17.63	18.80	19.09	20.56	22.03	23.50	24.96	26.44	27.92	29.38	30.84	32.31	33.78	35.25
	½	11.88	13.36	14.84	16.33	17.81	19.00	19.30	20.78	22.27	23.75	25.23	26.72	28.21	29.69	31.17	32.66	34.14	35.63
6 days	48	12.00	13.50	15.00	16.50	18.00	19.20	19.50	21.00	22.50	24.00	25.50	27.00	28.50	30.00	31.50	33.00	34.50	36.00

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